5.6.5 Survey Results for JICA's PV-Electrified Households

5.6.5.1 25W PV-Electrified Households

(1) Background

In January and February 1998, the JICA Study Team conducted an interview with 31 households at Geja, Turf and Manyoni, Kadoma district where a total of 100 JICA pilot solar systems were installed. At that time, the systems had been in use about 2 to 6 months.

(2) Family size, Job profiles

The average family size of households interviewed was calculated to be 10.4 (11.3 for Geja and 9.0 for Turf, Manyoni), higher than the 7.1 obtained from the entrusted interview survey (see section 5.6.2 (1). This is explained by the fact that some of the households consist of 1 husband, several wives, and naturally, a rather large number of children. Table 5-21 gives a job profile for the surveyed households in Kadoma, similar to the one shown in the previous section, introducing source of income, number of household members earning income, etc.

Table 5-21 Job Profile of PV-Electrified Households in Kadoma (JICA)

(1) Jobs

Rank	Household heads	%	Rank	Household members	%
1	Farming	66.6	1	Farming	47.4
2	Law/Security	10.0	2	Manufacturing	9.2
3	Teaching	6.7	3	Transportation	8.0
	Transportation	6.7	4	Teaching	6.9
				Business/Finance	6.9

(2) Job Profiles of PV-Electrified Households (%)

	Household heads			Household members		
	Geja	Turf	Kadoma***	Geja	Turf	Kadoma
Farming*	72.3	58.3	66.6	59.7	30.0	49.6
Salaried Jobs**	27.7	41.7	33.4	40.3	70.0	50.4

*Farming = Own Farm + Other person's Farm + Stock Farming

**Salaried jobs = Services + Construction + Teaching +Manufacturing + Business/Finance + Machine operation + Law/Securities + Clerk/Secretaries + Director/Manager + Government Officials

***Kadoma = Geja & Turf (including Manyoni)

(3) Job Combination (Household Heads and Members)

Kadoma

Rank	Household Head	Household Member	%
1	Farming	Farming	31.0
2	Farming	Manufacturing	5.7
	Farming	Transportation	
	Law/Securities	Farming	

Geja

Rank	Household Head	Household Member	%
1	Farming	Farming	40.4
2	Law/Securities	Manufacturing	8.8
3	Farming	Law/Securities	7.0

Turf/Manyoni

Rank	Household Head	Household Member	%
1	Farming	Farming	13.3
	Farming	Transportation	
2	Teaching	Farming	10.0
	Farming	Services	

Source: Zimbabwe field survey (1998)

(3) Housing Characteristics, Appliances, and Sources of Energy

Majority or 80% of households in Geja are modern type structures. For Turf and Manyoni, it is about an even split, i.e. half of households are of the traditional type, while the other half is modern. the average number of rooms per house is seven. Most of the households surveyed have radios, which they owned even before the PV systems were installed (powered by dry batteries or car batteries). The average length of usage per day is 6.3 hours.

A number of the households surveyed also own television sets, although most of the low-income ones (i.e. GTAI less than Z$10,000, no savings, or with outstanding loans) did not. Half of these who did already owned the TV sets before the PV systems were installed. Average length of usage per day was 2.5 hours, usually after 6 P.M. Average length of usage for lighting per day was also 2.5 hours.

Table 5-22 shows the monthly consumption of firewood and paraffin by the surveyed households. Average consumption of firewood is 183 kg (equivalent to about Z$18) per month at zero cost. About a fourth of households surveyed use the firewood for ironing. For paraffin, average monthly consumption is 4.4 liters worth about Z$9.2. Most of households surveyed place higher priority on money, education, and water before PV (see Table 5-23).

Table 5-22 Energy Sources used PV-Electrified households in Kadoma

	Firewood for cooking				Paraffin for lighting				
Area	Consumption	Equiv. Price[1]	Hours in use	Ironing ratio	Consumption	Price	Hours in use	No. of Wick lamp	% of floor polish
	kg/m	Z$/m	Hr/d	%	l/m	Z$/m	Hr/d		%
Geja	122	12.2	4.0	26.3	4.1	8.5	2.0	2.4	10.5
Turf	283	28.3	5.4	20.0	5.4	10.6	2.9	2.8	10.0
Kadoma[4]	183	18.3	4.4	24.1	4.4	9.2	2.6	2.5	10.3

Notes:

1)Value if not freely provided

2) Percentage based on number of households

3) Number of Wick lamp owned by one household

4) Kadoma district includes both Geja and Turf, Manyoni

Source: Zimbabwe field survey (1998)

Table 5-23 Priorities of PV-electrified households in Kadoma district

Rank	General priority	%	Rank	Energy source preference	%
1	Money	12.6	1	PV	32.6
	Education		2	Firewood	16.3
3	Water	9.2		Grid	
4	Electricity	8.0	4	Generator	10.5
5	Food	6.9			

Source: Zimbabwe field survey (1998)

(4) Income and Expenditures

Table 5-24 shows figures for GTAI in 1996, annual expenditures, and accumulated savings as of year-end. GTAI of Geja households was observed to be higher than those in Turf, Manyoni, presumably because of higher agricultural production in the former. In Kadoma, GTAI was pegged at Z$30,400, while average disposal income was about Z$24,500. Average annual consumption was estimated to be Z$22,200, explaining the low figure for average accumulated savings of Z$6,900 for end-1996.

Table 5-24 Income and expenditure of PV-electrified households in Kadoma

	Units	Geja	Turf, Manyoni	Kadoma
Gross Total Annual Income	Z$/y	31,806	28,028	30,373
Disposal income[1)]	Z$/y	25,560	22,682	24,468
Annual expenditure	Z$/y	24,438	17,970	22,128
Savings as of end-1996[2)]	Z$	8,338	4,444	6,936

Notes:

1) Calculated from income tax rate table (due to lack of available information)

2) Cumulative saving as of end-1996

Source: Zimbabwe field survey (1998)

(5) Problems Encountered with PV Systems

More than half of the households expressed satisfaction with the systems JICA installed. Some of the difficulties encountered include flickering of fluorescent tube during use, system breakdown, difficulty in charging and disconnection of battery terminal. The JICA Study Team and BUN technicians addressed all these concerns, however.

(6) Charge in Daily Life after installation of PV System

Followings are the change in daily life noted after the PV systems were installed (listed in order of rank):

Change in Lifestyle	%
Completing homework became easier for school children	27.7
Entertainment hours became longer	23.1
Interest in the outside world became greater	13.8
Knitting, sewing, and similar activities could be done at night	12.3
Dinner time became more enjoyable	6.2
Increased safety against intruders/animals at nighttime	6.2

Some 93% of the households surveyed expressed satisfaction with their systems, although a common sentiment was the limited capacity and difficulty of repaying the loan.

(7) Cost evaluation of JICA system

For the JICA systems, each household was requested to pay Z$750 as a connection fee and Z$75/month as a maintenance fee. More than half of the households regarded these amounts as being neither cheap nor expensive (see Table 5-25).

Table 5-25 Opinion of Kadoma Residents on JICA's Installation and maintenance Fees

(in %)

		Connection fee (Z$750)			Maintenance fee (Z$75/month)		
		Geja	Turf	Average	Geja	Turf	Average
A	Cheap	35.3	55.6	42.3	29.4	55.6	38.5
B	Neither expensive nor cheap	58.8	44.4	53.9	64.7	44.4	57.7
C	Expensive	5.9	0	5.9	5.9	0	3.8

Source: Zimbabwe field survey (1998)

Most or 82% of the households preferred an annual payment system, while 11% wanted to pay on a monthly basis. Residents interviewed also had some definite ideas about how the introduction/expansion of PV systems could provide popularity): raising poultry, selling cold soft drinks, knitting/sewing, running a barber shop, carpet cleaning, and milling. Among them, one household in Turf/Manyoni has started a knitting/sewing by receiving grains instead of money.

(8) PV Expansion Plans

For most households surveyed, any future expansion of their 25-watt systems would be used to power the following appliances (listed in order of preference): refrigerator, fluorescent tube, electric stove, television set, and radio/radio cassette. Most or 93% of them preferred to pay for the additional capacity on an 3-year installment basis. Table 5-26, which generates three scenarios using different assumptions for interest rate, shows that all households are willing to expand if current JICA terms continue to be applied, and that most will still do so if a low interest rate and a repayment period of 10 years is applied. If market rate are used, however, more than half of surveyed households (particularly those living in Turf) are not likely to expand. Most of the households who did not want to expand had "sum of disposal income and savings end-1996"of less than Z$20,000.

Table 5-26 Prospects for PV Expansion in Kadoma

	A			B			C		
	Current JICA Terms			Low interest rate (15%)			Current market rate (30%)		
Initial payment (Z$)	750			0			0		
Installment (Z$)	900			1,800			2,940		
Repayment period (year)	5			10			10		
Areas	Geja	Turf	Ave.	Geja	Turf	Ave.	Geja	Turf	Ave.
Will expand (%)	100	100	100	93.8	88.9	92.0	53.3	71.4	59.1
Will not expand (%)	0	0	0	6.2	11.1	8.0	46.7	28.6	40.9
Total (%)	100	100	100	100	100	100	100	100	100

Source: Zimbabwe field survey (1998)

5.6.5.2 56W PV- Electrified households

Among 101 households monitored in Kadoma district, 34 households increased PV capacity up to 56 watt PV system supplied by JICA, consisting of 1 panel, 3 fluorescent tubes, and 1 outlet for radio/TV, in August 1998. The JICA Study Team conducted an interview with 20 households expanded PV capacity at Geja and Turf in December 1998. At that moment, the new systems have been in use for about 4 months. As it could not obtain answers from all households surveyed for some questions, figures expressed in percentage are not always shown at intervals of 5%.

(1) Outline of the households surveyed

The average family size of the households interviewed was calculated to be 12. Number of rooms of the household was averaged 8. Most or 80% of household heads surveyed were found to engage in own farming, followed by business, transportation, government official. An average Gross Total Annual Income (GTAI) in 1997 was Z$29,300 after excluding two cases, shop and a farmer whose GTAI exceeds Z$100,000. Average saving at end-1997 was found Z$2,000.

(2) Appliances

Average profile of appliances surveyed are one radio, one TV, and three fluorescent tubes with average length of usage per day was 9.6, 2.5, and 2.5 hours respectively. Length of usage per day of an outer light, one among three observed in Geja was same as those of lights installed inside.

(3) Evaluation of connection and annual maintenance fees

For the enlarged 56 watt JICA PV system, each household was requested to pay Z$1,500 as a connection fee and Z$1,440/year as an annual maintenance fee. Two - third of the households surveyed regarded these amounts as being cheap and neither cheap nor expensive. Most or 90% of the households preferred an annual payment system for the maintenance fee, while 10% wanted to pay on a monthly basis.

(4) Satisfaction

As many as 70% of the households surveyed expressed big satisfaction with their new system, while 30% households expressed just about (nearly satisfied) due to limited capacity than the family's need.

(5) System troubles encountered

About half as 45% of the households surveyed experienced none of problems, while some of the difficulties encountered include switch breakdown, voltage fluctuation in use, system breakdown due to overuse, battery breakdown, charge controller breakdown, and defuses.

(6) New income generation

Two-thirds of the households interviewed raised some ideas for new income generation by use of PV system, include poultry, and knitting/sewing. One household in Turf started PV poultry business by 11 hours lighting a day for 100 chickens for 6 weeks as the first trial, resulting in Z$1,500 as sales amount with zero profit. That household started already the second batch for PV poultry.

(7) PV Expansion Plans

For most households surveyed, any future expansion of the PV systems would be used to power the following appliances (listed in order of preferences): refrigerator, electric stove, and fluorescent tube. Most or 74% of the household preferred to 56 watt system, followed by 21% for 25 watt system for future expansion if the same paying conditions as this time for JICA system is applied.

As a whole, expanded JICA PV system are preferred by the households in Kadoma district with their satisfaction.

5.6.6 Results of Survey of Public Institutions

(A) Clinics

(1) Clinics Surveyed

There were 591 unelectrified clinics in rural Zimbabwe as of end-1995. This is equivalent to about 48% of the national total of 1,232 (see Table 5-27). "Rural Zimbabwe" here is taken to mean the national figure minus the big cities of Harare, Bulawayo, and Chitongwisza.

Table 5-27 Number of Clinics in Rural Zimbabwe as of end-1995

Province	Modes of Electrification (in)			Piped water		Telephone		Total
	Electrified	UE	Electrified (%)	Available	None	Available	None	
MNL	144	84	63.2	199	29	152	76	228
M-C	59	46	56.2	66	39	68	37	105
M-E	80	80	50.0	112	48	119	41	160
M-W	118	53	69/0	125	46	124	47	171
MDL	32	60	34.8	80	12	33	59	92
MTN	44	60	42.3	101	3	68	36	104
MTS	101	107	48.6	113	95	158	50	208
MSV	63	101	38.4	125	39	83	81	164
Total	641	591	52.0	921	311	805	427	1,232

Note: MNL= Manicaland M-W= Mashonaland West MTS = Matabeleland South

M-C = Mashonaland Central MDL= Midlands MSV = Masvingo

M-E = Mashonaland East MTN= Matabeleland North

Sources: Ministry of Health and Child Welfare (1995)

Zimbabwe National Health Profile (1995)

The average number of employees (including nurses and nurse aids) for rural clinics is six. One clinic usually has 2 buildings, with 16 rooms all in all. Average for out-patients per month is 1,300, while number of deliveries per month is 8.6 (5.6 if grid-connected clinics are exluded). The most common sicknesses in 1996 (listed according to rank) were as follows: acute respiratory infections, diarrhea, sexually-transmitted diseases, malaria, skin diseases, and injuries from accidents.

(2) Priorities of Clinics

For majority of the rural clinics in Zimbabwe, electricity is the number one priority, followed by medicine, water supply, telephone, and regular visits to the clinics by physicians. This is due to the high number of deliveries and emergency outpatients in the evenings. As much as possible, most clinics prefer grid connection as their main source of energy, followed by PV, and then diesel generators. Average consumption amount of paraffin per month is 45.7 kg, used mainly to power refrigerators that store vaccines

Most clinics depend on donor contributions in order to continue operating. For 1996, some 45% of these clinics received higher than they got the previous year, while 35% received less. Majority, or 90% reported an increase in operating costs, however. The lack of a stable source of income might prove difficult for clinics to pay the monthly maintenance fee for PV installation.

(3) PV-electrified Clinics

Between the period 1990-1997, eight out of the 31 clinics surveyed were PV-electrified, as shown in the following table:

Table 5-28 Number of PV-Electrified Clinics in Rural Zimbabwe (1990-1997)

Year	90	91	92	93	94	95	96	97
Number	1	0	1	2	1	2	0	1
Capacity (Watt)	20		35	150 150	18	75 225		106

Source: Zimbabwe field survey (1997)

Some of the more common complaints about the PV systems installed was the limited power supply, failure of appliances to operate, and inability to use the system because of lack of sunshine. There was only 1 case of a stolen panel. For future expansion, most clinics hope to be able to use PV to power more fluorescent tubes, refrigerators, and radios.

(B) Schools

There are 6,169 schools primary and secondary schools in the whole of Zimbabwe, with a total student population of 3.2 million and 82,000 teachers. On the average, each school surveyed has 21 employees, 660 students, and 15 classrooms (see Table 5-29). Six schools follow a system of holding two classes in a classroom per day.

Table 5-29 Summary Details of Schools Surveyed

	Primary	Secondary	Total
Total number of schools	14	6	20
Number of schools with 2-classes/room system	4	2	6
Number of PV-electrified school	0	0	0
Number of grid-connected school	0	2	2
Number of teachers per school	18	28	21
Number of students per school	687	613	661
Number of classrooms per school	16	13	15

Source: Zimbabwe field survey (1997)

Most schools regard the availability of classrooms as their number one priority, followed by water, textbooks, a school library, and finally electricity. As an energy source, PV came out on top, followed by grid connection, diesel generator, and then paraffin. Fluorescent tubes, radios, and refrigerators came out as the top priorities of the schools for future PV expansion.

Average operating cost of a regular school is Z$84,000 and around Z$500,000 for a larger one. Students' tuition fees are the main source of income for the schools, although there is also some funds coming in from donations. Just like the clinics, it might be a problem for schools to allocate a regular budget for system maintenance.

Apart from the survey carried out by Southern Centre, the JICA Study Team made an independent survey (through face to face interviews) of three PV-electrified secondary schools near Mutare in Manicaland Province – Dora, Gwirindindi, and Karirwi. All three schools have in place two 83-watt PV panels connected to 17 fluorescent tubes, with one outlet for a TV or radio. Each school has an average of 28 employees, 767 students, 6 classroom buildings with 12 classrooms.

Homework is assigned every day of the week, with students requiring an average of 1 hour and 50 minutes per day to complete them. For these three schools, it is most important to have classrooms, followed by water, textbooks, and desks. PV came out as the most popular choice as a source of energy, followed by diesel generator, grid connection, and gas.

These schools are not required to pay the system fee (roughly equivalent to Z$30,000), but are given one-year free maintenance by installers. After this period expires, schools have to begin maintaining a separate budget for further maintenance. Schools will prepare the maintenance budget from General Purpose Fund and/or School Development Fund which are prepared by students' families. Some of the schools had TVs and radios hooked up, but these were mostly personal items of the teachers/staff.

All schools expressed satisfaction with their PV systems, but expressed a common desire for expanded capacity in the future to be able to connect applicances like refrigerators, electric typewriters, copying machines, television sets, and telephones to the systems. The expansion of PV is also expected to help students conduct science experiments. All three schools expressed preference for an installment payment scheme, with a downpayment of about half the system cost.

The budgets of Gwirindindi and Karirwi for 1996 were Z$280,000 and Z$160,000, respecitvely (see Table 5-30). No budgetary support is given by the Rural District Council, while teachers' salaries are paid by the national government.

Savings as of year-end was in the range of Z$30,000-50,000. One future plan of these PV-electrified schools is to hold night classes for adults who work during the daytime. It might take some time before this materializes, however, as most schools have no extra budget to hire extra teachers.

Table 5-30 School Budget (1/2)

1. School Name: Gwirindindi Secondary School (Zhawari village in Manicaland Province)
2. Supporting organization: Mutare Rural District Council (Prepared no budget for the operation of the school)
3. Term of the budget: 1997-1-1 -12-31
4. Name of School Head and Vice Head: Mr. Oswell Marange (Head) and Mr. C. T. Gumunya (Vice Head)
5. Number of employee including 1 night guard: 28 (27 teachers are living in 8 houses in the school site)
   Guard is living near the school in the village.
6. Number of students: 790 on 1998 February 04

A. Income		Z$/y	Z$/y
1. School Fees (Collected from parents)			
Form 1 & 2	195Z$/y x (201+201) x 0.95	74,470.50	
Form 3 & 4	255Z$/y x (168+134) x 0.95	73,159.50	
			147,630.00
2. Fund (Collected from parents)			
Building:	40Z$/y x 703 x 0.95	26,714.00	
Uniform:	90Z$/y x 703 x 0.95	60,106.50	
General Purpose :	6Z$/y x 703 x 0.95	4,007.10	
Practical:	45Z$/y x 703 x 0.95	30,053.25	
Sports:	30Z$/y x 703 x 0.95	20,035.50	
Total:	211Z$/y x 703 x 0.95		140,916.35
3. Total			288,546.35
Form 1 & 2	406Z$/y x (201+201) x 0.95		
Form 3 & 4	466Z$/y x (168+134) x 0.95		

B. Expenditure		Z$/y	Z$/y
1. Staff salary			
Clerk:	1,316.7 x 12:	15,800.40	
Clerk:	900 x 4	3,600.00	
Guard:	378 x 12	4,536.00	
Sub total		23,936.40	
2. Allowance			
Bonuses			
Clerk: 10% of the annual salary		1,500.00	
Guard: 10 % of the annual salary		453.00	
Relief Guard		200.00	
Sub total		2,153.00	
3. 1+2:			26,089.40
4. Staff salary from tution: 121460.6/27=4,498.5Z$/#			121,460.60
5. 1996 Deficit carried foreward:			
Textbook sales		17,110.00	
Maya		4,610.50	
Gestetner		518.88	
Wholesale Centre		10,888.51	
Saurombe		350.00	
Subtotal:			33,477.89
6. Grand total			181,027.89

Table 5-30 School Budget (2/2)

1. School Name: Karirwi Secondary School (Karirwi village in Manicaland Province)
2. Supporting organization: Karirwi Adventist Church (Prepared no budget for the operation of the school)
3. Term of the budget: 1996-1-1 -12-31
4. Name of School Head Mr. K. C. Marimanje
5. Number of employee including 1 night guard: 19 (18 teachers are living in 7 houses in the school site) Guard is living near the school in the village.
6. Number of students: 510 on 1998 February 04

A. Income		Z$/y	Z$/y
1. School Fees (Collected from parents)			
Form 1 & 2, Agriculture	330Z$/y x135	44,550	
Form 1 & 2, Fashion & Fabrics	360Z$/y x125	45,000	
Form 3 & 4, Agriculture	385Z$/y x100	38,500	
Form 3 & 4, Fashion & Fabrics	430Z$/y x 70	30,100	
2. Total			158,150

B. Expenditure	Z$/y	Z$/y
1. Operating expense		
Agriculture	6,000	
Bad debt preparation	5,000	
Books and stationery	30,000	
Deputy Head allowance	960	
Duplicator repaire services	2,000	
Fashion and Fabrics	8,000	
Food and entertainment	1,600	
Headmaster's allowance	9,600	
Insurance	2,000	
Secretary's Salary	19,500	
Sewing machines repaired/services	1,000	
Sports	6,000	
Typewriter services	500	
Uniforms (Form 1 and new comers only)	15,000	
Upkeep and maintenance	3,000	
Watchman's allowance	2,000	
Sub total		112,160
2. Capital expenditure		
Augumentation to grants	24,000	
Builder's Salaries	20,000	
Two sewing machines	2,000	
Sub totals		46,000
3. Grand total		158,160

(出所) Field survey in rural Zimbabwe in 1998

5.6.7 Results of Interviews with Village Leaders

The wide acceptance of JICA's PV systems is, to a large extent, due to the support given by the village leaders/regional development councils, especially in the pre-installation stage when the Study Team first introduced the idea to the target households/public institutions. Apart from the general survey conducted, therefore, the Study Team saw it fit to separately interview village leaders, i.e. councilors, officers, resettlement head, headmasters, etc., to get their "comprehensive" view on the installation of PV systems in their respective areas. Said interviews were conducted using the same questionnaire for households, and their comments/opinions are summarized as follows;

- Solar power is quite popular in the village of Geja and Turf primarily because of the AFC loan facility;
- The JICA solar scheme is a welcome development in both villages, as it provides cheaper connection fees and lower repayment fees than the GEF program, uses local solar companies as installers, monitors the progress of the systems, and included schools as beneficiaries;
- There is a need for better loan facilities for the technology to become more popular in these areas;
- PV is the best source of electricity for lighting a clinic at nighttime. Expanded capacity is anticipated in order to connect bigger appliances like refrigerators and sterilizes in the future;
- The introduction of PV in schools is a very welcome development as it paves the way for the holding of night classes and facilitating more difficult scientific experiments by students in the school lab;
- The JICA systems are very well-received, but there is a common desire by users to expand the existing capacity of 25 watts. Most households want to expand lighting to include 5 rooms, and connect appliances like irons and electric cooking apparatus;
- Of the households benefiting from the JICA systems, some of the more common problems encountered include: theft, breakdown of stem/pole, fluctuation of voltage during use, loose wire connection at battery terminals, corrosion of battery terminal, low levels of pure water in the batteries, and poor system installation.

The cases of theft usually occur in public institutions where no one/few people are around at night/during weekends. Some people have taken to installing alarms in their systems to guard against thieves.

5.7 Demand forecast

5.7.1 Methodology of PV demand forecast

(1) Households

In order to forecast the demand for PV systems by rural households (DRH) in Zimbabwe, it was first necessary to obtain data on the forecasted population starting from 1996. This was followed by the calculation of the number of unelectrified households using figures for rural-urban ratio, average rural family size, and ratio of unelectrified households. The number of unelectrified households is multiplied by 50, the average PV capacity of each household in order to finally determine the future rural household demand for PV.

It is conceded that not all rural households will be able to afford PV electricity. This makes it necessary to compute the ratio of households that can afford PV to the total figure. To do this, the following procedure was done:

1. Calculate ratio of lighting expenditures to total expenditures (L)

   L = total lighting expenses ÷ total expenses

   During the most recent field study in Zimbabwe, this figure was 2-3%.
2. Calculate cost of electricity (CE), assuming different scenarios for economic growth (low and high-growth).
3. Determine minimum GTAI level for PV electrification (GPV)

   Necessary condition: GPV=CE/GTAI ≥ 4%
4. Calculate ratio of households that can afford PV (HPV)

   HPV = GPV ÷GTAI obtained during first study
5. Calculate demand for PV among rural households (DPV)

   DPV = HPV * DRH

Figures used for GTAI and electricity cost are actual figures for 1996 (excluding inflation and levies). Two assumptions for GTAI growth are forecasted regional GDP growth rates of 3% and 5% (the target).

Table 5-31 Ratio of Lighting and Fuel Expenses to Total Expenditures (%)

Electrification	UE	PV	GE	Average
Firewood	1.7	1.4	1.1	1.4
Other fuel	1.1	1.4	4.3	1.7
Paraffin	1.0	1.8	0.4	1.3
for lighting	(0.6)	(0.7)	(0)	(0.5)
for others	(0.4)	(1.1)	(0.4)	(0.8)
Dry battery	2.9	0.6	0.5	1.3
PV	0	1.4	0	0.8
Grid electricity	0	0	4.4	1.0
Total lighting etc.	3.5	2.7	4.9	3.6

Note: Total lighting etc = paraffin for lighting + dry battery + PV + Grid electricity

Source: Zimbabwe field survey (1997)

(2) Public Institutions

The total number of the unelectrified public institutions, i.e. clinics and schools, in the rural areas per unit number of rural population was calculated using actual 1996 data on rural population, unelectrified ratio, and number of present public institutions in 1996.

Future PV demand is calculated by multiplying this index by the rural population and the average number of PV units demanded by public institutions.

It was assumed that electric fees of rural clinics will be shouldered mainly by donor organizations, while and those for schools will be covered by students' fees. It was also assumed that residences of clinic and school staff are to be electrified by PV. The sum of these two comprises total demand for PV in public institutions.

5.7.2 Assumptions

(1) For both of household and clinic

a. Population forecast

The Study Team assumed a 3% population growth rate based on actual 1985-1996 figures obtained from the CSO National Accounts (1997). For the period 1985-1990, average growth was plotted as 3.14% per annum, while for the period 1990-1996, the average was 3.33%. For 1992-1996, this figure was 3.41%.

As shown in Figure 5-6, the Study Team's forecast, 3%/year rate, dropped in center among other compared cases including 3 cases in Census 1992 by CSO, and population forecast as a basis of wood fuel demand forecast conducted by DOE of MOTE.

	Fertility	Mortality
Case 1.	Linear decrease	Constant
Case 2.	Constant until 2002	Constant
Case 3.	Linear decrease	Linear decrease

It should be noted that the JICA Study Team extended the forecast (which was originally only to 2007) up to 2017.

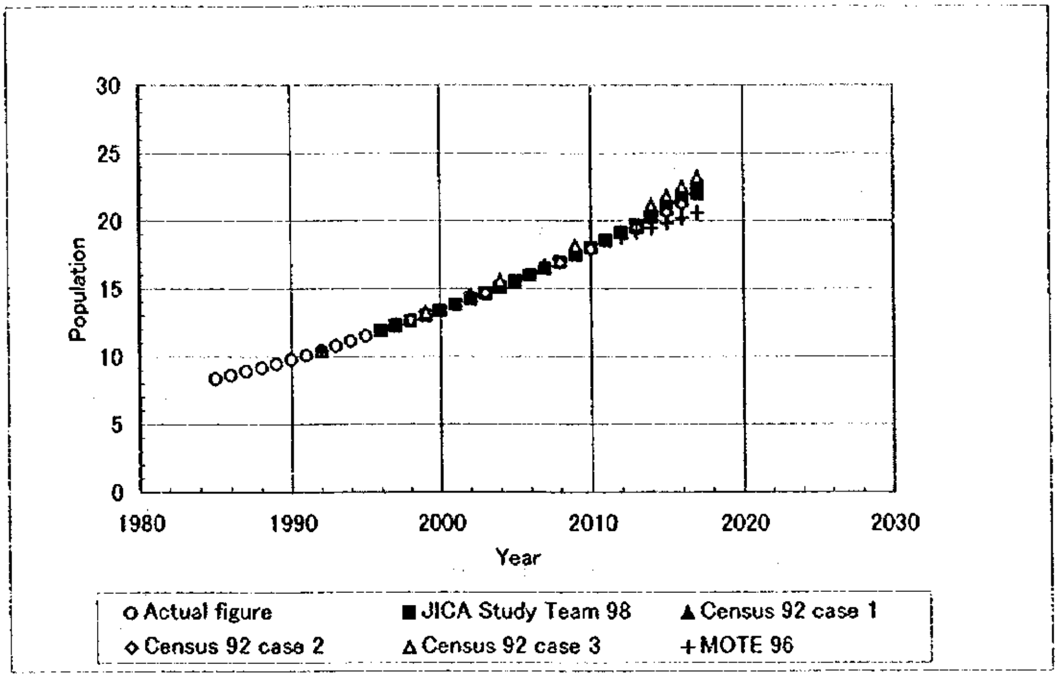


Figure 5-6 Forecast of population in Zimbabwe

Source: Zimbabwe field survey (1997 and 1998)

b. Ratio of Rural to Total Population

It was assumed that the ratio calculated by the CSO until 2007 applies beyond this period. The Study Team followed this trend in extending the forecast up to 2017 by use of logistic function. The figures are as follows:

Year	1992	1997	2002	2007	2012	2017
Ratio of Rural to Total Population	69.4	66.6	64.0	61.2	60.6	58.2

c. Household Size

Although the average household size obtained during the last field survey was 7.1, the figure used for the calculations was 5.16, taken from the 1992 Census, given that this covers a bigger sample size.

d. National Electrification Ratio

The Study Team assumed that 95% of rural Zimbabwe is unelectrified, following the 5% electrification ratio of the ZESA survey.

(2) Households

a. System Size/Capacity

A 50-watt PV system was assumed for the household installations expected to power 5 fluorescent tubes and one outlet for a TV or radio. This was based on present capacity of PV-electrified households and survey results (particularly the current beneficiaries' plans for future expansion).

b. Gross Total Annual Income (GTAI)

The average obtained for unelectrified households in six provinces was Z$26,200. This figure was modified by the Study Team to get an average figure for eight provinces, however, incorporating new information taken from the ZESA report. The new average was computed to be Z$23,000. Two cases for determing real growth of GTAI were carried out, one assuming a 3% growth/year, and the other one assuming the 5% target of the Ministry of Industry and Commerce.

c. PV Electricity Fee

Various figures for PV electricity fee can be calculated assuming different figures for PV system capacity, system cost, and other indicators. For this Study's concerns, 3 cases were generated for a 50-watt system: Z$1,400 (almost equal to fee being charged by JICA for its systems); Z$3,400 (almost equal to the average repayment amount paid by PV-electrified households); and Z$2,100, the midpoint/median of the two previous figures. Four cases were then generated using a combination of assumptions for system price and interest rate. Results are as follows:

	PV Electricity Fee	System price	Repayment Interest Rate	Minimum income required
Case 1	Z$1,426	Z$ 7,600	15% /y	Z$35,300
Case 2	Z$2,067	Z$ 7,600	30%/y	Z$51,700
case 3	Z$2,184	Z$ 13,050	15%/y	Z$54,600
case 4	Z$3,353	Z$ 13,050	30%/y	Z$83,800

(3) Public Institutions

(3)-1. CLINICS

a. Number of Clinics

The number of clinics per million people was assumed to be 118.4, the average of figures obtained between 1995 and 1997. The figures for these years were derived by dividing forecasted rural population by the no. of rural clinics (from the CSO Quarterly Digest of Statistics, September 1997). Actual figures are shown below:

	1995	1996	Average
Rural population (in millions)	7.815	8.014	
No. of rural clinics	926	948	
No. of clinics per million people	118.5	118.3	118.4

b. System Size/Capacity

Capacity of rural clinics was assumed to be 233 watts, based mainly on survey results. This system is expected to power total seventeen 7-watt fluorescent tubes, 1 light for use overnight (13 hours), 1 outlet for a TV/radio (to be used 8 hours in the waiting room), 2 lights for night deliveries (13 hours on a fortnightly basis). It was also assumed that refrigerators currently running on paraffin will not be connected to an 83-watt PV panel. Three residences of clinic employees will also be PV-electrified, each using a 50-watt system.

(3)-2 Schools

a. Number of Schools

A total of 520 schools (primary and secondary) per million persons was assumed, following actual figures for 1995-1997. The number of rural schools (obtained from CSO Facts and Figures 1997) was obtained by multiplying this figure with the total rural population.

	1995	1996	1997	Average
National population (in millions)	11,526	11,908	12,265	
Number of schools	6,169	6,185	6,200	
Number of schools per million people	535.2	519.4	505.5	520

b. Number of Unelectrified Schools

The number of unelectrified schools is assumed to be the same as number of unelectrified clinics, which is 48% of the total number.

c. System Size/Capacity

It was assumed that 499-watt systems would be installed in the schools, powering seventeen 17-watt fluorescent tubes and one outlet to be used for 3 hours, 15 classrooms (each with 2 fluorescent lights), 2 laboratories (to be used 1 hour), and 5 residences of teachers/school employees (each one with a 50-watt panel).

5.7.3 Results of PV Demand Forecast

Forecast of PV demand both for unelectrified households and public institutions (clinics and schools) in rural Zimbabwe are summarized in Table 5-34.

(1) PV Demand Forecast for Unelectrified Households

It was observed that PV electrification fee and capability of households to pay are inversely related, i.e., the lower the electrification fee, the higher the capability to pay. It was also noted that the capability of households to pay seems to increase every year. This is quite logical as GTAI continues to grown yearly as well (see Figure 5-7).

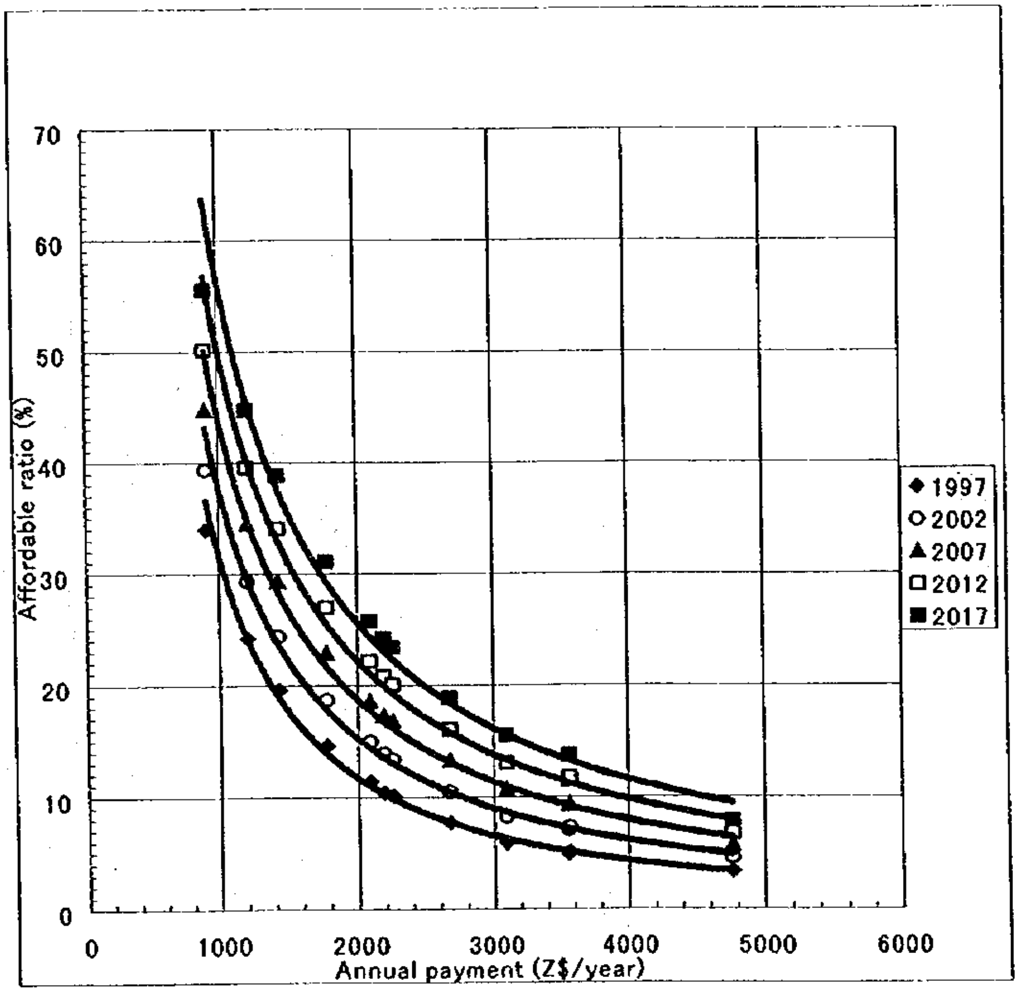


Figure 5-7 Relationship Between Annual Electricity Fees and Acceptable PV Fee for rural PV households

Table5-32 PV demand forecast for unelectrified households and Public Institutions

Item	Units	1996	1997	2002	2007	2012	2017
Population	Million	11.908	12.265	14.219	16.483	19.109	22.152
Rural dwell ratio	%	67.3	66.8	64.0	61.2	58.2	55.2
Rural population	Million	8.014	8.193	9.100	10.088	11.121	12.228
Rural family size	Person	5.16	5.16	5.16	5.16	5.16	5.16
Rural households	Million	1.553	1.558	1.764	1.955	2.155	2.370
Rural unelectrified ratio	%	95	95	95	95	95	95
Rural unelectrified households	Million	1.475	1.508	1.675	1.857	2.048	2.251
PV demand for households							
Growth rate of GTAI = 3%/y							
Electricity fee: Z$1428/y	Affordable . %	19.1	19.6	24.4	29.3	34.1	38.9
Z$2087/y	Affordable . %	11.2	11.4	15.0	18.6	22.2	25.8
Z$2184/y	Affordable . %	10.1	10.4	13.9	17.3	20.8	24.2
Z$3353/y	Affordable . %	4.9	4.9	7.1	9.3	11.5	13.7
Electricity fee: Z$1428/y	Af. HH. Mil	0.282	0.296	0.409	0.544	0.698	0.876
Z$2087/y	Af. HH. Mil	0.165	0.172	0.251	0.345	0.455	0.581
Z$2184/y	Af. HH. Mil	0.149	0.157	0.233	0.321	0.426	0.545
Z$3353/y	Af. HH. Mil	0.072	0.074	0.119	0.173	0.235	0.308
Electricity fee: Z$1428/y	MW	14.1	14.8	20.4	27.2	34.9	43.8
Z$2087/y	MW	8.3	8.6	12.6	17.3	22.7	29.0
Z$2184/y	MW	7.5	7.8	11.6	16.1	21.3	27.2
Z$3353/y	MW	3.6	3.7	5.9	8.6	11.8	15.4
Growth rate of GTAI = 5%/y							
Electricity fee: Z$1428/y	MW	14.1	15.2	23.8	34.2	46.2	60.2
Z$2087/y	MW	8.3	8.6	15.4	23.5	33.1	44.2
Z$2184/y	MW	7.5	7.7	14.2	21.9	31.0	41.7
Z$3353/y	MW	3.6	3.6	8.0	13.2	19.4	26.6
PV demand for public institution							
Rural clinics, 233 watts							
No. of rural clinics	No.	952	973	1081	1198	1321	1453
Unelectrified clinics	No.	457	467	519	575	634	697
PV demand for clinics	MW	0.1	0.1	0.1	0.1	0.1	0.2
Rural school, 499 watts							
No. of rural schools	No.	4167	4260	4732	5246	5783	6359
Unelectrified schools	No.	3709	3791	4211	4669	5147	5660
PV demand for schools	MW	1.9	1.9	2.1	2.3	2.6	2.8
Public Institutions' demand	MW	2.0	2.0	2.2	2.4	2.7	3.0

Source: Field survey in rural Zimbabwe in 97

In 1997, number of affordable rural households for PV system and PV demand for rural households is forecast to be 70,000 and 4 megawatts (MW) if electricity fee of Z$ 3,400,then,300,000 households and 15 MW if Z$1,400. Average of the two is 160,000 and 8 MW. For the case of 3%/year GTAI growth rate, future forecast number of affordable rural households and PV demand for households is to be 310,000 and 16 MW on the average, ranging from 170,000 to 540,000, and from 9 to 27 MW by the year 2007, when the figure is 540,000 and 27 MW (from 310,000 to 880,000, and from 15 to 44 MW) following an annual growth rate of 6.3%/year. For the case of 5%/year GTAI growth rate, future PV demand is forecasted to be 22 MW on the average, ranging from 13 to 34 MW in 2007. Figure for 2017, is 41 MW (from 27 to 60 MW) at a growth rate of 8.4%/year.

Demand for PV for households is summarized as follows:

Growth rate of GTAI	Units	1996	1997	2002	2007	2012	2017
3%y	MW	8	8	12	16	21	27
5%/y	MW	8	8	14	22	31	41

Conditions for PV demand forecast for households in rural Zimbabwe is summarized as follows:

Table 5-33 Conditions for PV demand forecast for households in rural Zimbabwe

Case		Capacity (W)	Interest (%/year)	Electricity fee (Z$/year)	Necessary minimum GTAI (Z$/year)
1	Ideal price	50	15	1,426	35,700
2	Ideal price	50	30	2,087	51,700
3	Market price	50	15	2,184	54,600
4	Market price	50	30	3,353	83,800

Source: Field survey in rural Zimbabwe in 1998

(2) PV demand of Public Institutions

Among 973 of rural clinics in 1997, it is estimated 467 clinics are to be electrified using PV. PV demand for clinics is estimated to be 0.1 MW at 233 watt for the unit capacity of clinic, followed by 0.1 MW in 2007, and 0.2 MW in 2017.

Unelectrified schools are estimated to be 3,791 among 4,260 in 1997. PV demand for schools is estimated 1.9 MW at 499 watt for the unit capacity of school, followed by 2.3 in 2007, and 2.8 MW in 2017. Total PV demand for public institutions, consisting of clinics and schools, is estimated 2.0 MW in

1997, 2.4 MW in 2007, and 3.0 MW in 2017, much smaller than those for households.

The technology transfer regarding procedure for PV demand forecast quantitatively related to the electricity fee, GTAI of the household, affordable ratio has been carried out to the official of DOE as the counterpart.

(3) Themes for the Promotion of PV Electrification

One of the most important issues that needs to be addressed in the promotion of PV electrification is the preparation of an appropriate budget to pay for regular electricity fees, particularly by public institutions including schools and clinics. This may prove difficult, however, as both types of public institutions generally suffer from lack of funds. For schools, this is particularly difficult since their main source of income is tuition fees by the students. No income is derived from donor organizations. Clinics, meanwhile, rely almost exclusively on donor organizations, and cannot usually count on fees from out-patient to provide the extra money. A possible solution that could help assist these public institutions in augmenting their current sources of income is to sell the spare electricity they will derive from their PV systems in order to cover their regular electricity fees.

6

ECONOMIC EVALUATION

6.1 Introduction

Roughly 28.2% of Zimbabwe is electrified at present, with rural areas having a low electrification rate of 4.6%, as opposed to a high 71.7% rate in urban areas. ZESA is the implementing agency for rural electrification in the country, but is at times constrained by budgetary issues in carrying out this mandate. Investment costs for rural electrification are very expensive because customers are usually located far from the existing grid. Moreover, electric power demand in rural areas is usually very small since customers have only lighting requirements, resulting in a long cost recovery period.

In this study, the economic evaluation will weigh the costs and benefits of rural electrification by PV systems and by grid extension, considering the needs and repayment capabilities of the rural residents. The prospects for expansion of the PV industry in Zimbabwe and the possibility of lowering the cost of PV systems will also be examined.

It should be noted that the figures used in this section were based on data gathered in March 1997, one month after the Study commenced. They do not reflect the drop in the Zimbabwe dollar (and the subsequent rise in consumer pries) towards the end of the same year.

6.2 Outline of the GEF Project

The ongoing GEF solar project in Zimbabwe, undertaken in cooperation with UNDP and the Government of Zimbabwe (GOZ), has been installing PV systems in rural areas since 1993. Funds of US$7 million plus Z$4 million (about US$400,000) in kind were allocated respectively by the GEF and GOZ.

The original project target was to install 9,000 systems (45W equivalent) within a period of 5 years, but by year end-1997, this was exceeded with about 9,800 equivalent systems in place. To make the systems more affordable to low-income customers, AFC extended low interest loans using funds from UNDP/GEF project (discussed in more detail in Chapter 7).

There are several PV manufacturing companies in Zimbabwe which import components for assembly into systems such as charge controllers, PV modules, fluorescent lights, etc. Table 6-1 shows samples of PV system prices in Zimbabwe obtained during the first field study.

On the average, the breakdown of total cost of a PV system is as follows: 37% module, 19% lights, 14% battery, 6% charge controller, 8% installation, and 16% other. In addition, customers usually are charged significantly at a rate of Z$3/km for transportation costs, as most of them live in rural areas located far from PV installing companies. As a result, the share of transportation in total system cost often is rather high.

As shown in Table 6-1, the total price of the small system is lower than the large one but the price of the large system on a per watt basis is lower than the small one. This is explained by the fact that in small systems, the prices of modules, batteries, and lights are directly correlated to the system's capacity. The prices of these items, change more or less in step with the size of the system. Therefore, the smaller the system, the lower the cost of these components (and vice versa). Meanwhile, the prices of other equipment such as charge controllers, mounts for PV modules, installation cost and transportation cost changes little regardless of the system's capacity. This inflates the per Wp price of small systems – for the smallest system (20Wp), for instance, the share of the charge controller in the total cost is about 15%.

Table 6-1 Examples of PV System Price in Zimbabwe

(Unit: Z$)

NO of Lights	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Solar Panel Type	MSX 20	VLX 32	P 250	MSX 50	MSX 50	MSX 60	MSX 60	MSX 83	MSX 83	MSX 83	MSX 50	MSX 50	MSX 50	MSX 60	MSX 60	Total	Share
No of Solar Panels	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2		
Solar Panel Unit Price	2,307	2,714	3,406	4,008	4,008	4,561	4,561	6,264	6,264	6,264	4,008	4,008	4,008	4,561	4,561		
Solar Panel(s)	2,307	2,714	3,406	4,008	4,008	4,561	4,561	6,264	6,264	6,264	8,016	8,016	8,016	9,122	9,122	86,649	37%
Charge Controlle Rostar 12	889	889	889														
Prostar 20				1,052	1,052	1,052	1,052	1,052	1,052	1,052	1,052	1,052	1,052	1,052	1,052	15,291	6%
Battery(ies) 12-60G	1,090	1,090	1,090					2,180	2,180	2,180							
Battery(ies) 12-100G				1,650	1,650	1,650	1,650				3,300	3,300	3,300	3,300	3,300	32,910	14%
Light(s) SLH	365	730	1,095	1,460	1,825	2,190	2,555	2,920	3,285	3,650	4,015	4,380	4,745	5,110	5,475	43,800	19%
Voltage Dropper	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	975	0%
Battery Box	165	165	165	165	165	165	165	200	200	200	200	200	200	200	200	2,755	1%
Module Mount	310	310	310	310	310	310	310	310	310	310	620	620	620	620	620	6,200	3%
Electrical Spare	700	800	900	1,000	1,100	1,400	1,500	1,600	1,700	1,800	1,900	2,000	2,100	2,200	2,300	23,000	10%
Spare Tubes	55	110	165	220	275	330	385	440	495	550	605	660	715	770	825	6,600	3%
Total Equipment Price	5,946	6,873	8,085	9,930	10,450	11,723	12,243	15,031	15,551	16,071	19,773	20,293	20,813	22,439	22,959		
Installation cost	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400	1,500	1,600	1,700	1,800	1,900	18,000	8%
System Cost	6,446	7,473	8,785	10,730	11,350	12,723	13,343	16,231	16,851	17,471	21,273	21,893	22,513	24,239	24,859	236,180	
Sales Tax 15%	967	1,121	1,318	1,610	1,703	1,908	2,001	2,435	2,528	2,621	3,191	3,284	3,377	3,636	3,729		
Grand Total	7,413	8,594	10,103	12,340	13,053	14,631	15,344	18,666	19,379	20,092	24,464	25,177	25,890	27,875	28,588		
Transport Cost Z$3/km																	

(Source) PV Installer

6.3 Current Situation of Power Supply System

6.3.1 Power Generation

ZESA is the main agency responsible for supplying electricity throughout Zimbabwe, both in the urban and rural areas. Power supplied in 1995 was 10,495 GWh, 4% higher than the previous year. Power came from five ZESA power plants supplying a total of 7,323 GWh and imports from Zambia, Zaire, and South Africa totaling 3,172 GWh.

Of the five power plants mentioned above, four plants (Hwange, Munyati, Harare, Bulawayo) are coal-fired thermal facilities while the other one (Kariba) is a hydropower plant. The Hwange and Kariba plants account for more than 90% of the total output, as the remaining three plants are small-scale and have been operating for more than 50 years, thus having low efficiency.

The following table provides more details about each of these plants:

Table 6-2. Current Situation of 5 Major Power Plants in Zimbabwe (1995/96)

Name	Output (Gwh)	Capacity (MW)	Plant factor (%)	Thermal efficiency (%)	Coal consump. (kg/kWh)
Hwange	4,634.9	920	62.23	28.06	0.505
Munyati	247.2	120	25.11	18.13	0.652
Harare	175.7	135	16.42	21.47	0.564
Bulawayo	102.4	120	10.53	19.16	0.645
Kariba	2,163.1	666	37.04	81.65	
Total	7,323.3	1,961	45.09	43.24	0.517

Source: ZESA (1996) Annual Report and Accounts

6.3.2 Transmission and Distribution Lines

ZESA has several kinds of transmission and distribution lines -- 420 kV, 330 kV, 220 kV, 132 kV, 110 kV, 88 kV, 66 kV, 33 kV, 22 kV, and 11 kV for transmission lines and 225/390 V for low voltage distribution line. The total length of transmission and distribution lines in Zimbabwe is now 58,683 km, broken down by type as follows:

22 kV	15,307 km
11 kV	30,974 km
225/390 V	12,402 km
TOTAL	58,683 km

Expansion of the power transmission network is now being planned and transmission lines of more than 11 kV will be increased by about 2.7 % through a loan from the Africa Development Bank (AfDB). The Ministry of Transportation and Energy is also proceeding with rural electrification development based on a master plan study for rural electrification completed by an Indian consultant.

6.3.3 Electricity Tariffs

Electricity tariffs in Zimbabwe are collected from the following kinds of consumers: domestic, mining & industrial, commercial, and agricultural customers, and government (mainly for public lighting).

For domestic customers, there are basically three kinds of collection systems – conventional meter, prepayment meter, and a fixed fee system for load-limited customers. The conventional meter system includes a basic monthly charge of Z$19.08 plus a per kWh charge of 19.14c/kWh for the first 300kWh, and 44.63c/kWh for any additional usage. The prepayment meter system (using a prepaid card), meanwhile, involves a fixed charge of 34.08c/kWh. Finally, the load limited system involves a fixed monthly charge based on Ampere rating. Under this system, the charge for domestic customers is set lower than other sectors.

6.3.4 Calculation of Generation Cost

The generation cost of a Zimbabwe coal-fired power plant was calculated using information obtained from ZESA. The assumptions used are summarized as follows:

ITEM	ASSUMPTION
Construction cost	US$560 million
Power plant capacity	660 MW
Interest rate	10% (assumption)
Power plant life time	30 years
Plant factor	80%
Coal price	Z$100/ton
Heat rate	5,893 kcal/kg
Efficiency	32%
Operation & maintenance cost	US1.4\times 10^{-3}$/kWh
Percentage of own use	6%
Exchange rates	Z$10.8/US$

The calculations (shown in Table 6-3) yielded a result of 23 cents/kWh. This approximates the average generation cost of 17.3 cents/kWh (which includes the hydropower plant) quoted in the ZESA Annual Report.

Present electricity rates, set on the basis of average generation cost, come to about half of the long-run marginal cost (which ZESA calculated based on the Power Development Plan released in January 1996). As a result, ZESA is planning to gradually increase electricity rates in order to meet the long-run marginal cost in the future.

Table 6-3 Net Generation Costs of Coal-Fired Power Plants

Descriptions	Unit	C.P.P	Note
1. Total Construction Costs	1000 US$	560,000	
2. Installed Capacity	MW	660	
3. Construction Cost per kW	US$/kW	848	
4. Interest During Construction	US$/kW	85	10 % of construction cost
5. Total Investment per kW	US$/kW	933	
6. Life Time	Years	30	
7. Discount Rate	%	10%	assumption
8. Capital Recovery Factor		0.11	
9. Annual Capital Cost per kW	US$/kW	99	
10. Plant Utilization Factor	%	80%	
11. Annual Operation Hours	Hours	7,008	
12. Capital Cost per kWh	US$ x 10^{-3} /kWh	14.13	
13. O/M Costs	US$ x 10^{-3} /kWh	1.40	
14. Fuel Price	US$/ton	9.26	(Z$10.8/US$)
15. Heat Content	kcal/kg	5,893	
16. Thermal Efficiency	%	32.00	
17. Heat Rate	kcal/kWh	2,688	
18. Fuel Consumption for 1 kWh	kg/kWh	0.456	
19. Fuel Cost for 1 kWh	US$ x 10^{-3} /kWh	4.22	
20. Generation Costs	US$ x 10^{-3} /kWh	19.75	
21. Power House Own Use	%	6%	
Net Generation Costs	US$ x 10^{-3} /kWh	21.01	
		0.23	Z$/kWh

6.4 Economics of PV System Installation & Operation

For this study, 100 households received PV systems in Turf/Manyoni and Geja, areas in the in Kadoma District. The basic system consisted of a 25Wp PV module, a 12V-60Ah car battery or a 12V-40Ah deep cycle battery, two 7W fluorescent lights or one fluorescent light, and an outlet for a television or radio.

SYSTEM COMPONENTS	COST (in Z$)
25Wp PV module	1, 600
Charge controller	600
Battery	560
Fluorescent lights (2)	440
Battery box	165
Mount pole for the PV module	380
Cable and other attachments	500
Total	4,245

When installing this kind of system, 15% for sales tax, Z$600 for construction costs, and Z$3/km for transportation costs should be added to the total cost above.

6.5 Cost Comparison Between PV and the Existing System

In this section, the respective costs per kWh of electrification by PV and grid extension are compared. In doing so, transportation cost is not included. Fluorescent lights and indoor wiring (which are the responsibility of the household) are also excluded.

6.5.1 PV System

Households for PV system installation under this project are located in Kadoma District. Meteorological data (solar irradiation) obtained in Kadoma was only for the 10 years from 1970 to 1980. Average monthly irradiation for this period was as follows:

(kWh/m^2)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
6.55	6.43	6.22	6.00	5.46	5.22	5.30	6.10	6.67	6.90	6.77	6.19

As the PV modules were at 17.5 degrees latitude, the irradiation quantity at 17.5 degree was calculated as follows:

(kWh/m²)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
5.71	5.55	5.79	5.99	5.95	5.78	5.86	6.51	6.77	6.53	6.05	5.41

Based on the above data, the annual output of a 25Wp PV system was calculated to be 22.79 kWh (refer to Table 6-4). (The method of calculation is discussed in more detail in Section 3.1.3).

Table 6-4 Annual Electricity Generation of 25Wp PV Systems in the Kadoma Area

	Insolation ($kWh/m^2/day$)	Total loss	Output (kWh/d)	Monthly output (kWh/month)
January	5.71	59%	0.06	1.81
February	5.55	59%	0.06	1.76
March	5.79	59%	0.06	1.83
April	5.99	59%	0.06	1.90
May	5.95	59%	0.06	1.89
June	5.78	59%	0.06	1.83
July	5.86	59%	0.06	1.86
August	6.51	59%	0.07	2.06
September	6.77	59%	0.07	2.15
October	6.53	59%	0.07	2.07
November	6.05	59%	0.06	1.92
December	5.41	59%	0.06	1.71
				22.79

Other assumptions concerning the cost and life of the system used in calculating generation cost are as follows:

ITEM	ASSUMPTIONS
Capacity of the system	25W
System price	Z$3,157
Life of system	20 years
Annual output (receiving end)	22.79kWh/year
Price of battery including sales tax	Z$644/peace
Life of battery	2.5 years
Number of batteries	1
Price of charge controller including sales tax	Z$690
Life of the charge controller	5 year
Annual maintenance cost	1% of total capital investment cost
Interest rate	10%

Note: System price excludes fluorescent lights and indoor wiring.

The system price of Z$3,157 was arrived at by adding the cost of the charge controller, battery, fluorescent lights, cable and other attachments, adding an assumed installation cost of

Z$600, and then applying a 15% tax. The interest rate of 10% was assumed on the basis of current rates for low interest finance sourced abroad. The annual maintenance cost of 1%, meanwhile, was arrived at by using the results of the social survey.

Using the above data, generation cost per kWh of a 25Wp-PV system was calculated. Total annual cost for power generation included annual fixed costs, variable costs (battery and charge controller replacement costs), and maintenance costs.

For PV systems purchased using bank loans, principal and interest are repaid to the bank every year. In this case, annual fixed cost is annual payment returned as principal plus interest. It is derived by multiplying the borrowed amount by the capital recovery factor.

1) Fixed cost per kWh

The price of the system is Z$3,157.

When interest rate is 10% and repayment period is 20 years, capital recovery factor is calculated as follows:

$$CRF = (R(1+R)^n)/((1+R)^n-1)$$

$$= (0.1(1+0.1)^{20})/((1+0.1)^{20}-1)$$

$$= 0.117$$

Where: R=interest rate and n=repayment period

Therefore, annual fixed cost of the system is:

System price × Capital recovery factor (CRF)

= Z$3,157 × 0.117

= Z$369/year

Fixed cost per kWh is:

Annual fixed cost ÷ Annual output

= $369/year ÷ 22.79kWh/year

= Z$16.19/kWh

2) Variable cost per kWh (battery and charge controller replacement)

Battery replacement cost of the system is calculated as follows:

Battery price × Number of batteries

= $644/peace × 1

= Z$644

Annual cost for battery replacement is:

Battery replacement cost ÷ Battery life year

= Z$644 ÷ 2.5 years

= Z$258/year

Battery replacement cost per kWh is:

Annual battery replacement cost ÷ Annual output

= Z$258/year ÷ 22.79kWh/year

= Z$11.32/kWh

Charge controller replacement cost of the system is:

Charge controller price × Number of charge controllers

= Z$690/piece × 1

= Z$690

Annual cost for the charge controller replacement is:

Charge controller replacement cost ÷ Charge controller life year

= Z$690 ÷ 5 years

= Z$138/year

Charge controller replacement cost per kWh is:

Annual charge controller replacement cost ÷ Annual output

= Z$138/year ÷ 22.79kWh/year

= Z$6.06/kWh

Therefore, the cost for the battery and charge controller replacement is:

Z$11.32/kWh + Z$6.06/kWh = 17.38/kWh

3) Maintenance cost per kWh

In this evaluation, annual maintenance cost is assumed to be 1% of total capital investment cost (system price). Annual maintenance cost is therefore Z$31.57.

Maintenance cost per kWh is:

Z$31.57/year ÷ 22.79kWh/year = Z$1.39/kWh

From the above calculation, generation cost of PV system was calculated to be Z$34.96/kWh, consisting of fixed, variable (battery and charge controller replacement cost), and maintenance costs.

6.5.2 Extension of 11kV Transmission and Distribution Line

To carry out rural electrification by grid extension, an 11kV transmission line, an 11/0.4 kV transformer, and a low voltage distribution line for each household are necessary. Per unit costs of the 11kV transmission line (wood pole and $50mm^2$ conductor), 25kVA transformer (11/0.4kV), and low voltage distribution line (wood pole and $50mm^2$ conductor) are Z$133,568.80/km, Z$31,386.88, and Z$149,461.22/km respectively (Please refer to Table 6-5 to 6-7). These figures do not include transportation costs.

Assuming that a village that is 5 to 10 km away from the existing grid is electrified by transmission line extension, that there are 50 households in the village, and that demand for power in the village is 0.06 kWh/day/household (same as the case of the PV system to be able to compare costs) the extension cost for 5 km is as follows:

Extension costs of 11kV transmission line is:

Z$133,568.80/km×5km=Z$667,844.00

The cost of the 25kVA transformer (which drops from 11 kV to 230 V for households) is Z$31,386.88.

Assuming that the length of the distribution line needed to connect 50 households to the transformer is 1 km, the distribution line cost is:

Z$164,438.82/km×1km=Z$164,438.82

Total costs for village electrification by grid extension can be calculated as follows:

11kV line cost + Transformer costs + Distribution line costs

= Z$667,844.00 + Z$31,386.88 + Z$164,438.82

= Z$863,669.70

When interest rate is 10% and repayment period is 20 years, capital recovery factor (CRF) is:

$$(R(1+R)^n)/((1+R)^n-1)$$

$$=(0.1(1+0.1)^{20})/((1+0.1)^{20}-1)$$

$$=0.117$$

Therefore, annual fixed cost for grid extension is:

Total cost for grid extension × CRF

= Z$863,669.70 × 0.117

= Z$101,049.40/year

Annual power consumption in the village is:

22.79kWh/year·household × 50 households = 1,140kWh/year

Therefore, grid extension cost per kWh is:

Annual fixed cost ÷ Annual power consumption

= Z$101,049.40/year ÷ 1,140kWh/year

= Z$88.64/kWh

Assuming that the electric cost at the receiving end in Zimbabwe is Z$0.2/kWh, the electric cost in the village is:

Extension cost + Electric cost

= Z$88.64/kWh+Z$0.2/kWh

= Z$88.84/kWh

This cost is 2.5 times that of electrification by PV. Going through the same calculations for grid extension by 10 km, the cost arrived at is Z$157.20/kWh. Both results are high compared to electrification using PV.

Table 6-5 Costs for 11kV Line with Wood Poles (Conductor Size 50mmsq.)

Item No.	Description	Size or Voltage	Quantity	Unit Price		Total	
				Forex (Z$)	Local (Z$)	Forex (Z$)	Local (Z$)
1	SCA Conductor (meter)	50mmsq.	3090	24.20	0.00	74,778.00	0.00
2	Wood Poles	11 meters	9		530.00	0.00	4,770.00
3	Pin Insulators	11 kV	21	440.00	0.00	9,240.00	0.00
4	Disc Insulators		18	990.00	0.00	17,820.00	0.00
5	Stay Insulators		2		30.00	0.00	60.00
6	Insulator Pins	11 kV	21		8.00	0.00	168.00
7	Wood X-Arms	5" 6'	7		15.00	0.00	105.00
8	Channel X-Arms	4 x 2	2		50.00	0.00	100.00
9	Strain Clamps		6	275.00	0.00	0.00	0.00
10	Galvanised Stay Wire (meter)	7/12	60		3.00	0.00	180.00
11	Stays Complete	8 x 5/8"	4		36.20	0.00	144.80
12	Galvanised Earth Wire (meter)	7/14	120		3.00	0.00	360.00
13	Earth Rods	8 x 5/8"	2		25.00	0.00	50.00
14	Earth Connectors		2		12.00	0.00	24.00
15	PG Clamps	60/2	6		4.50	0.00	27.00
16	Twisted Shackles		6		9.00	0.00	54.00
17	Pole Top Brackets	11 kV	7		7.50	0.00	52.50
18	Pole Caps Asbestos		9		3.00	0.00	27.00
19	Pin Spacers	11 kV	7		4.50	0.00	31.50
20	Armour Tape (kg)		1		110.00	0.00	110.00
21	Binding Wire (kg)	8 Gauge	2		50.00	0.00	100.00
22	Spiral Nails (kg)		1		34.00	0.00	34.00
23	Fencing Staples (kg)		3		14.00	0.00	42.00
24	Braging Straps		14		10.00	0.00	140.00
25	Creosote (litter)		210		3.75	0.00	787.50
26	Galvanised Bolts & Nuts	M20 x 160	14		15.00	0.00	210.00
27	Galvanised Bolts & Nuts	M20 x 200	11		15.00	0.00	165.00
28	Galvanised Bolts & Nuts	M20 x 240	7		15.00	0.00	105.00
29	Galvanised Bolts & Nuts	M20 x 300	7		17.00	0.00	119.00
					Sub-total	101,838.00	7,966.30

Total material costs	109,804.30
Labar costs	6,342.48
Sub-total	116,146.78
Sales tax	17,422.02
Grand total	133,568.80

(Source) Rural Electrification Master Plan Study of Zimbabwe, WAPCOS

Table 6-6 Costs for Transformer 25kVA 11/0.4 kV

Item No.	Description	Bin No.	Quantity	Unit Price		Total	
				Forex (Z$)	Local (Z$)	Forex (Z$)	Local (Z$)
1	Transformer 25kVA 11/0.4kV	T	1	19,059.00	0.00	19,059.00	0.00
2	Wood poles(11m)		2		530.00	0.00	1,060.00
3	Lighting Arrestors 11kV	A3	3	150.00	0.00	450.00	0.00
4	D Fuse Mounts	F36/C7	3	430.00	0.00	1,290.00	0.00
5	Solid Links	F36/19	3		62.00	0.00	186.00
6	X-Arms for D Fuse, Transformer, L.A	C57/4	4		25.00	0.00	100.00
7	PVC Cable 16mm sq. 4 Core(meters)	C4/11M	12		50.00	0.00	600.00
8	0.075 Copper Conductor (meters)	C37/6A	30		15.00	0.00	450.00
9	Cable End Box 16mm	C13/25	1		10.00	0.00	10.00
10	PG Clamps 25mm sq.	C100/95	6		8.50	0.00	51.00
11	Line Taps	C38/3	12		5.75	0.00	69.00
12	0.06 Line Taps	C38/2B	6		6.50	0.00	39.00
13	A.C.B. 50A 440V	B50	1		210.00	0.00	210.00
14	A.C.B. Cover	B50	1		15.00	0.00	15.00
15	Meter Test Unit	M16	1		27.00	0.00	27.00
16	Angle Iron (kg)	I36/9	15		3.65	0.00	54.75
17	Neutral Link	L8/1A	1		80.00	0.00	80.00
18	Crimping Lags (2.5 x 6mm sq.)	L32/18	6		1.00	0.00	6.00
19	Crimping Lags (16 x 12mm sq.)	L32/35	12		2.75	0.00	33.00
20	Crimping Lags (16 x 16mm sq.)	L32/36	8		2.75	0.00	22.00
21	U Bolts	B9/10	1		40.00	0.00	40.00
22	Cable Gland No.2	C109/42	1		25.00	0.00	25.00
23	Cable Shroud No.2	C109/42A	1		8.00	0.00	8.00
24	Earth Rods 8' x 5/8"	E7/5	4		25.00	0.00	100.00
25	Earth Clamps	E7/6	4		12.00	0.00	48.00
26	Crosby Clamps 3/8"	C63/1	2		16.00	0.00	32.00
27	ZESA Grey Paint (litter)	P1/15	5		27.00	0.00	135.00
28	Small ZESA Padlock	P10	1		19.00	0.00	19.00
29	Danger Notices	P15/2	2		23.00	0.00	46.00
30	Fencing Staples (kg)	S45/2	1		11.00	0.00	11.00
31	Rolls Adhesive Tap Black	T68/1	3		4.50	0.00	13.50
32	Flat Washers 3/8"	W11/2	12		1.00	0.00	12.00
33	Flat Washers 0.5"	W11/3	4		1.50	0.00	6.00
34	Flat Washers 3/4"	W11/5	10		1.00	0.00	10.00
35	Wood Pole Washers	W14	12		2.50	0.00	30.00
36	S.W.B. Wire Green	W30/15	2		1.20	0.00	2.40
37	Nuts & Bolts (25 x 10mm)	B6/19M	12		2.00	0.00	24.00
38	Barbed Wire	W45	1		11.00	0.00	11.00
39	Nuts & Bolts (25 x 12mm)	B6/35M	12		2.10	0.00	25.20
40	Nuts & Bolts (90 x 12mm)	B6/14M	3		2.00	0.00	6.00
41	Nuts & Bolts (200 x 10mm)	B6/98M	12		15.00	0.00	180.00
					Sub-total	20,799.00	3,796.85

Total material costs	24,595.85
Labar costs	2,697.09
Sub-total	27,292.94
Sales tax	4,093.94
Grand total	31,386.88

(Source) Rural Electrification Master Plan Study of Zimbabwe, WAPCOS

Table 6-7 Costs for L.T Line with Wood Poles (Conductor Size 50mmsq.)

Item No.	Description	Quantity	Unit Price		Total	
			Forex (Z$)	Local (Z$)	Forex (Z$)	Local (Z$)
1	HDA Conductors 50mm sq. (meters)	4,120	22.00	0.00	90,640.00	0.00
2	PVC Cable 70mmsq. 4 Core (meters)	120		90.00		10,800.00
3	Wood Poles (9meters)	26		346.00	0.00	8,996.00
4	Asbestos Pole Caps	26		3.00	0.00	78.00
5	Galvanised Wire (meter)	240		2.00	0.00	480.00
6	LV Insulators	148	88.00	0.00	0.00	0.00
7	Stay Insulators	20		30.00	0.00	600.00
8	Stay Wire (meters)	300		3.00	0.00	900.00
9	Stay Rods	20		19.00	0.00	380.00
10	Stay Washers	20		2.00	0.00	40.00
11	Stay Bows	20		20.00	0.00	400.00
12	Stay Plates	20		19.00	0.00	380.00
13	PG Clamps 50mm sq.	40		4.50	0.00	180.00
14	Line Taps 25 mm sq.	26		6.50	0.00	169.00
15	Cable Glands #4	8		59.00	0.00	472.00
16	Cable Glands Shrouds	8		8.00	0.00	64.00
17	Cable Glands	4		8.00	0.00	32.00
18	Binding Wire (kg)	20		50.00	0.00	1,000.00
19	ACB Covers	4		15.00	0.00	60.00
20	Fibre Washers	296		1.55	0.00	458.80
21	Saddles 1.25"	36		3.20	0.00	115.20
22	LV D-Irons	32		2.57	0.00	82.24
23	Fencing Staples (kg)	10		14.00	0.00	140.00
24	Wood pole Washers	148		2.50	0.00	370.00
25	Creosote (liters)	210		3.75	0.00	787.50
26	Bolts & Nuts 200mm x 200mm sq.	148		15.00	0.00	2,220.00
				Sub-total	90,640.00	29,204.74

Total material costs	119,844.74
Labar costs	10,121.54
Sub-total	129,966.28
Sales tax	19,494.94
Grand total	149,461.22

(Source) Rural Electrification Master Plan Study of Zimbabwe, WAPCOS

6.6 Sensitivity Analysis

In section 6.5, electricity cost per kWh of PV system was found to be cheaper than grid extension because the electricity load is very small (demand is basically two fluorescent lights per household) and the distance between the existing grid and the village is 5-10 km.

This section compares the respective cost advantages between grid extension and PV electrification when certain variables such as demand of electricity and distance of extended transmission line change. To simplify the calculation, the cost of PV electrificity per kWh installed is assumed to remain constant. It is also assumed that the number of households in a village electrified by grid extension is 50.

Figure 6-1 shows the break-even point when demand of electricity is constant at 0.06 kWh/day-household. In this case, when the length of the extended transmission line is less than 1 km, a grid extension is more economical than a PV system. When the distance of the extended transmission line is 10 km, however, the electricity cost through a grid extension is four times higher than that of a PV system.

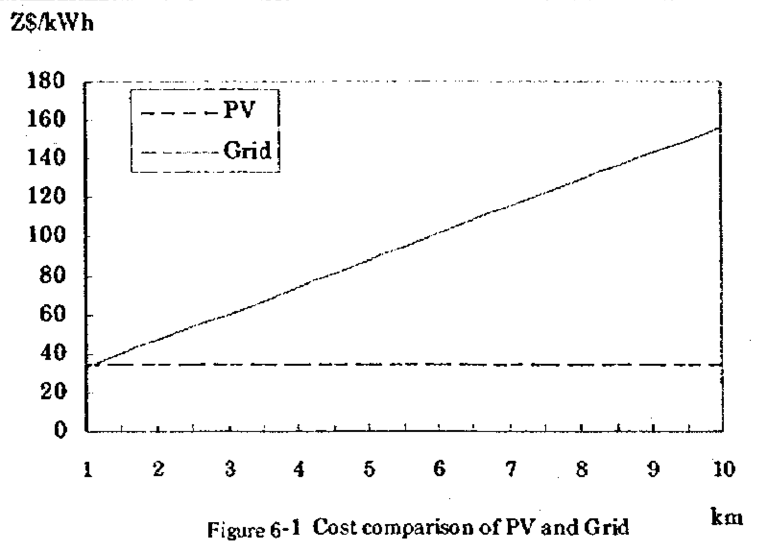


Figure 6-1 Cost comparison of PV and Grid
(Load is constant)

Figure 6-2 shows the break-even point in the case of 5-km and 10-km grid extensions when a household's demand for electricity increases. In the case of 5 km, when demand is less than 0.16 kWh/day/household, PV electrification is more economical. In the case of 10 km, when demand is less than 0.28kWh/day-household, PV electrification is more economical.

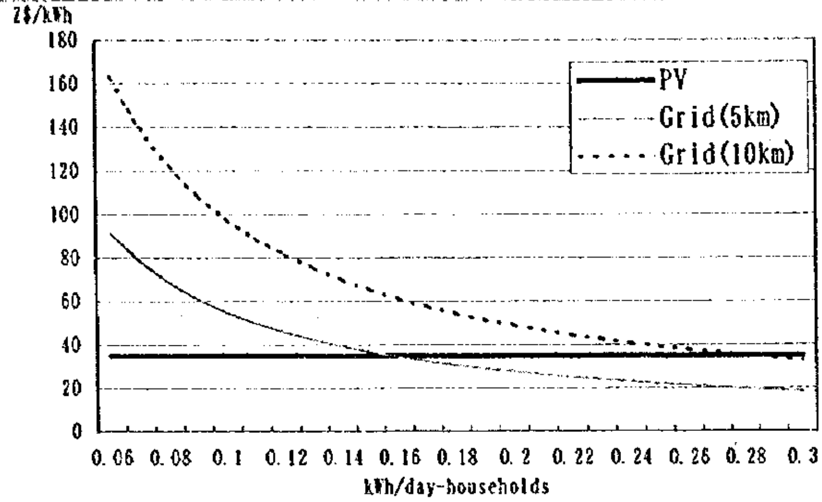


Figure 6-2 Cost Comparison of PV and Grid (Distance from existing grid is constant)

In each of the two villages of Geja and Turf, 50 JICA PV systems were installed, with each system consisting of one 7 Watt fluorescent lamp and one outlet for a television set. Data loggers were installed in some selected systems, and by the third field study in Zimbabwe, the data gathered by each one were collected and analyzed.

It was observed that in most households where a data logger was installed, the users seemed to have a good awareness of the system capacity, knowing how to maximize their use, i.e. turning off the fluorescent lamp while they were watching TV, and turning off the TV while the fluorescent lamp was in use. It was also determined that the average usage time of use is three hours (usually after sunset). Daily electric power consumption was observed to reach about 30 W/h. In this kind of situation, PV electrification is clearly more economical than grid extension (see Figure 6-2).

Interviews with rural residents revealed that all households were very satisfied with the JICA systems, but expressed their wish to increase the current capacity. This is rather logical, given than households in rural areas normally have 3 to 4 rooms. If the beneficiary expands the PV system and uses 4 fluorescent lights, the power consumption a day becomes 0.12kW in which case PV electrification remains more economical than grid extension.

Generally speaking, electrification using PV can not be considered "total electrification" because of limitations on consumption. Typical PV systems, for instance, can not be economically used to power refrigerators and electric heaters. Nevertheless, lifestyles of rural people are greatly improved with the use of electric lights and television because they allow for continued activity during nighttime and also for the expansion of knowledge through greater exposure to the outside world seen on TV.

Whether or not PV systems are economical in comparison with a grid extension depends mainly on the distance from the grid and the volume of electricity demand. For villages with a high concentration of residents located between 10 and 20 km from the grid, detailed evaluation of the two above-mentioned factors is necessary. For all other cases, i.e. located more than 20 km from the grid, however, it can be concluded that electrification using PV is more economical.

The grid is extended in Zimbabwe every year. However, it is not practical to expect people to wait for 10 or 20 years to receive electricity when alternatives are available. In spite of the restrictions on electricity consumption, it is necessary to move ahead with electrification using PV systems in order to improve the people's quality of life. That is to say, electrification using PV system could be introduced as "pre-electrification," or an intermediate step preceding full electrification based on connection to the power grid.

6.7 Zimbabwe's PV Industry

The PV industry in Zimbabwe is still in the development stage and its scale it not large. However, the prospects for rural electrification using PV in Zimbabwe are good. Proof of this is the UNDP/GEF project, which was specifically aimed at its wider adoption.

On more general terms, the GEF project is an undertaking on a worldwide scale that is intended by the UNDP and the World Bank as a measure to counteract environmental problems. The name of the project in Zimbabwe is "Photovoltaics for Household and Community Use." It aims to reduce the generation of carbon dioxide through the use of photovoltaics as an energy source.

The UNDP/GEF project got underway in 1993 under the management of the PMU. It is scheduled to finish at the end of June 1998. Until now, it has been possible to procure a stable supply of PV products thanks to the GEF project, their credit scheme, and because a public organization such as the AFC was involved. However, if we consider what will happen after the GEF project is gone, it is clear that private companies will have to take orders from persons wanting to purchase PV equipment. These companies will have to procure the component parts of these PV systems and install them. However, these small private companies will usually need an advance payment in order to enable them to order the necessary products and parts in sufficient quantities from overseas manufacturers.

There are two problems involved here. The first is the possibility that overseas suppliers will not fill orders immediately if the quantities ordered are small. The second is the problem of whether the private companies have sufficient capital investment to pay for their orders in advance. When we consider these two issues, it becomes clear that it will be very difficult in some respects for the private companies involved in the PV business in Zimbabwe today to procure the goods they will need.

On the other hand, we must consider the point of view of the rural residents. The most likely way for residents to obtain the funds to purchase PV systems is by borrowing money at a high rate of interest from commercial banks. Even if they will be able to obtain credit, it will still be necessary for the residents to ask the installation companies directly to install the systems. They will no longer be able to go through a public organization with the GEF acting as a liaison. In addition, complaints and requests for assistance regarding the systems will also have to be made directly to the private company, and no public organization will be there to provide any guarantees.

The installation companies that currently exist are mainly small operations with little capital investment, few employees, and not much experience. It is clear that when the GEF project is gone and it becomes difficult for rural residents to obtain credit, the number of people interested in PV systems will shrink to below the current level. With sales dropping and insufficient operating capital, many companies will go out of business and those that remain will have a difficult time providing adequate after-sales service.

At present, approximately 60 companies are registered with SEIAZ. However, it is still too early for these companies alone to be able to achieve the widespread adoption of PV systems throughout Zimbabwe. It would seem that a public organization like the GEF is necessary to achieve smooth procurement and widespread distribution of PV systems.

The GEF project is managed by the PMU and the credit scheme is being handled by the AFC. The AFC has branch offices in many regions. This makes it easy for rural residents to make loan payments. However, with regard to management, the PMU has only one office, in Harare. Once the systems have been installed, PMU staff must travel to the rural regions in order to perform tasks such as inspection or checking equipment. It is not a simple or inexpensive matter to access many villages spread over a wide area. Also, as the number of systems installed increases each year, the workload of the PMU staff, whose numbers are limited, increases. In this sense, there have been real problems with the management of the PMU, since it lacks branch offices throughout the country. In the future, if a public organization promotes PV systems, an organization, which has rural branch offices and covers the technical aspect is desirable.

Marketing efforts are an important part of the functions carried out by the installers of PV systems. The residents of regions that have not yet been electrified lack information from the mass media. For this reason, it is difficult for them to obtain information on PV systems, and many people have misconceptions regarding PV systems. For example, some rural residents think that electricity from PV systems can be used in exactly the same way as electricity from the power grid.

Before they can sell the PV systems, the PV installation companies need to provide an adequate explanation of how such systems work. PV installation companies should supply instruction manuals along with the systems. If residents use the systems improperly or if they overuse them they break down (or if residents mistakenly think their systems have broken down), the installation company will have to dispatch personnel to distant regions to perform inspections and repairs when needed.

Some installation companies have already begun supplying such manuals with their systems, and this helps to raise the level of knowledge among local residents. As with manuals accompanying typical electrical home appliances, these should contain information on the equipment specifications, how to use the system, simple maintenance procedures, and troubleshooting. If residents use the systems properly, problems are fewer and the burden on the suppliers is lessened. This in turn plays a big role in spreading the perception that the systems are reliable and contributes to their widespread adoption.

To promote further PV use in Zimbabwe, government should seriously examine policies aimed at protecting the local industry. During the duration of the GEF project, PV equipment bought overseas (through the PMU) was exempted from import duties. Duties were applied, however, when local manufacturing companies procured intermediate products. In the end, the locally-manufactured products turned out to be more expensive than their imported counterparts and were not competitive.

There are two possible policy approaches to protect the local industry. One is to protect domestic products by imposing duties on the imported products (as these would increase the retail prices of imported systems). However, the local industry grows as a result of this kind of policy and the prices of products do decline, the import duties have to be modified correspondingly.

In the case of Zimbabwe's PV industry, it seems more appropriate to use another approach, i.e., protecting local products through subsidies. As already mentioned, the local PV industry in Zimbabwe is still in the developing stage. Using subsidies as a form of support to its local industry would not only be more transparent but also easier to judge/evaluate as a policy measure.

There are basically two ways by which subsidies can be applied. One is to lower the price of domestic goods to the international level and another is to channel funds into research and development to upgrade the quality of local PV components to international standards.

6.8 The Economic Effects of Using PV Systems

6.8.1 Effects to GDP

The Gross Domestic Product (GDP) of Zimbabwe in 1996 reached Z$85,585 million while total population was estimated to be 11,900,000. GDP per capita was thus about Z$7,187. The country's main industries are agriculture, manufacturing, and distribution (commerce). Put together, the production of these three sectors represents more than half of the total figure, with agriculture contributing 17.8%, manufacturing, 17.1%, and commerce, 18.3%. The manufacturing sector is concentrated in the large cities of Harare and Bulawayo, where more than 70% of total production is carried out.

The country's employed population is roughly 1,250,000, or 10.5% of the total. This figure does not include people employed by small companies in rural areas or self-employed individuals. Twenty seven per cent of this figure is engaged in farming, while 15% work in the manufacturing sector. Only 8% belong to the commercial sector. It is estimated that rural residents make up about 1/3 of Zimbabwe's total employed population.

When considering the effects that widespread adoption of PV systems would have on the economy of Zimbabwe, note that sales by installation companies fall into the construction industry category as part of GDP, and sales by PV manufacturers fall into the category of the manufacturing industry.

GDP is the value of goods, minus the cost of materials and other intermediate consumption. It is therefore an overall value added. Generally speaking, about 40% of the value of product sales by a manufacturer can be counted as value added based on past Zimbabwe statistics. Also, in the case of installation companies, most of the installation cost is accounted for by personnel and management costs. Since raw materials costs include only the small value of materials used for installation, such as electrical wiring and conduit, approximately 80% of the installation cost can be assumed to be value added.

Also, with the introduction of the PV system, it is not necessary to supply the household electricity through grid. Thus electricity costs such as generation cost, purchase cost from foreign countries (100% of imported electricity), foreign currency of construction costs of transmission and distribution line (90% of total construction costs) are saved and counted as benefit of PV system. The effects that the introduction of PV system gives GDP in Zimbabwe are as follows.

PV system production of added value (40% of total sales of PV system)

+ PV construction of added value (80% of total sales of PV system construction)

+ Purchase electricity from foreign countries (100% of electricity demand)

+ Facility costs of transmission and distribution line (90% of total cost)

In 1997, number of systems was about 3,500 (in 45W equivalent). The cost per system was approximately Z$10,000, and the installation cost was about Z$800. Using these values as the basis for calculation, the value of one year's sales of PV systems comes to Z$35,000,000 and the value added to this is 40%, or Z$14,000,000. On the other hand, the sales of the PV installation companies were Z$2,800,000, for a value added of Z$2,240,000. The total value added associated with the PV industry was therefore Z$16,240,000.

Purchased electricity that is saved by PV system is as follows.

3,500 households * 22.79kWh/year * Z$0.2/kWh = Z$15,953

Annualization factor at 10% of discount rate for 20 years is 8.5136. Therefore, the present value of the generation cost that is saved becomes Z$135,817 as follows.

Z$15,953 * 8.5136 = Z$135,817

In the same way, because 90% of the materials of the transmission and distribution line is regarded as imported from a foreign country, 90% of these costs are benefits. Total transmission line cost for 3,500 households is Z$10,017,660 (assuming one transmission line /200 - 250 households: Z$667,844 * 15). Total transformer cost is Z$2,197,082 because it is necessary to install one transformer of Z$31,386.88 for 50 households (Z$31,386.88 * 70). Total cost of distribution line is Z$11,510,717 (cost of distribution network for 50 households is Z$164,438: Z$164,438 * 70). When totaling these, Z$21,352,913 is invested as the capital costs from the following formula.

(Z$10,017,660 + Z$2,197,082 + Z$11,510,717) * 0.9 = Z$21,352,913

When totaling the above figures, the total benefits become Z$37.7 million as follows.

PV system production of added value (40% of the sales)	Z$14,000,000
PV construction of added value (80% of the construction sales)	Z$2,240,000
The electricity purchase	Z$135,817
The facility costs of transmission and distribution	Z$21,352,913
The total	Z$37,728,730

Table 6-8 shows the trend in Zimbabwe's gross domestic product. According to this table, GDP for 1996 was Z$85,585 million. Of this, Z$14,668 million was accounted for by the manufacturing industry and Z$1,943 million was accounted for by the construction industry. In comparison with these figures, the PV industry share accounted for 0.04% of GDP, 0.26% of the total for the manufacturing industry, and 1.9% of the total for the construction industry. These figures show that the PV industry does not presently have a large effect on the economy of Zimbabwe. These figures are the effects of concentrating all benefits of 3,500 PV systems of 45W equivalent in 1997. Therefore, if a similar scale of PV system installation repeats the following year, the same benefit will be expected.

6.8.2 Cost-Benefit Analysis of PV system

It was found that the benefit of the production and operation of 3,500 PV systems in 1997 gave a positive effect to GDP. Also, these activities decrease the electricity import expense and the power transmission expense. Moreover, when considering purchasing electricity from foreign countries and importing materials for transmission lines, these saved expenses are regarded as a decrease in imports. When considering the materials for PV systems that were imported in 1997 as costs and the saved electricity import expense and the saved transmission costs as benefits, the following cost and benefit analysis results.

Investment cost in 1997

Imported PV materials	Z$21,000,000
Imported materials for installation	Z$560,000
Saved transmission costs	-Z$21,352,913
Total	Z$207,087

Expense of annual electricity after 1998	Z$15,953
Expense of electricity for 20 years (present value: 10% of discount rate)	Z$135,817
Cost-benefit ratio	0.66
Internal rate of return	4.5%

	Year	Cost	Benefit	Net benefit
0	1997	21,560,000	21,352,913	-207,087
1	1998		15,953	15,953
2	1999		15,953	15,953
3	2000		15,953	15,953
4	2001		15,953	15,953
5	2002		15,953	15,953
6	2003		15,953	15,953
7	2004		15,953	15,953
8	2005		15,953	15,953
9	2006		15,953	15,953
10	2007		15,953	15,953
11	2008		15,953	15,953
12	2009		15,953	15,953
13	2010		15,953	15,953
14	2011		15,953	15,953
15	2012		15,953	15,953
16	2013		15,953	15,953
17	2014		15,953	15,953
18	2015		15,953	15,953
19	2016		15,953	15,953
20	2017		15,953	15,953
		Benefit/cost 1.0		IRR 4.5%

A cost benefit analysis was carried out using the PV system costs and the benefits of the reduction of transmission line and imported electricity as above. As the result of the analysis, costs and benefits were almost same under our assumptions of 3,500 45Wp PV systems, 22.79kWh/year-household electricity demand, Z$0.2/kWh electricity cost, establishment of one transmission line per 200-250 households, installation of one transformer per 50 households, and one kilometer of distribution line per 50 households. However, if the assumption of transmission line length changes, the analysis results change significantly.

6.8.3 Other Benefits

Relative to GDP, the local PV industry in Zimbabwe represents a very small, seemingly insignificant percentage. However, looking at it in terms of the regional economy, the economic effect of PV can be quite substantial.

For unelectrified areas in Zimbabwe where agriculture is the main industry, employment opportunities are rather limited. With more widespread PV use, the surplus labor force (which becomes rather bloated during the off (non-farming) season) can find employment, if only on a temporary basis, in, say, system installation. For self-employed individuals, meanwhile PV can contribute significantly by making it possible for them to extend their working hours into the evening, increasing their productivity. Even for restaurants, bars, and similar public establishments, the use of PV systems to provide lights and entertainment can increase sales significantly.

The JICA experience offers concrete proof of the employment opportunities that PV can bring about. During installation of JICA's systems local persons were employed by the installing companies. Maintenance is also being carried out by BUN, a local NGO. For many people in Zimbabwe the project opened up many opportunities for involvement, e.g. provision of maintenance service, setting up small manufacturing businesses for PV mountings, poles, etc.

With the spread of PV-powered televisions in rural areas in Zimbabwe, a greater number people are also better informed. Simple information on market trends and expected weather conditions during the farming season, for instance, can allow farmers to make more informed decisions that will lead to greater productivity, and in turn, higher income.

Considering how PV can improve people's lifestyles, increase their productivity, and boost the regional economy, it becomes quite apparent that expanded use of PV can have very significant economic effects.

Table 6-8 Trend of Gross Domestic Product by Industry at Current Prices (Z$ million)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Agriculture, Hunting, and Fishing	1,885	1,672	1,470	2,092	2,346	3,188	4,013	2,322	5,836	9,593	9,636	15,283
Mining and Quarrying	336	446	336	680	602	845	1,184	1,552	1,625	2,531	3,151	3,846
Manufacturing	1,651	2,019	2,315	2,747	4,022	4,403	7,138	9,251	8,930	10,701	11,931	14,668
Electricity and Water	135	207	301	351	424	543	700	913	1,234	1,810	2,014	2,409
Construction	211	278	359	464	466	615	813	1,082	1,152	1,330	1,550	1,943
Finance and Insurance	610	633	872	944	1,222	1,336	1,668	2,790	3,211	4,577	4,872	6,370
Real Estate	175	203	250	343	432	474	562	840	995	1,177	1,429	1,526
Distribution, Hotels and Restaurants	1,462	1,765	1,615	2,075	2,503	3,267	4,481	5,818	6,926	8,609	12,112	15,630
Transport and Communication	443	598	688	808	954	1,185	1,409	1,515	2,807	3,124	3,636	4,200
Public Administration	494	575	717	773	929	1,215	1,440	1,596	1,886	2,366	2,941	3,324
Education	487	610	847	812	952	1,269	1,635	1,946	2,362	2,955	3,441	3,602
Health	139	164	190	230	271	316	401	460	544	791	923	1,042
Domestic Services	96	129	142	296	319	348	401	447	474	565	621	828
Other Services	397	348	385	454	609	770	1,030	1,310	1,657	1,998	2,209	2,795
Less Imputed Bank Service Charge	-205	-233	-284	-299	-338	-425	-590	-522	-833	-1,289	-1,016	-1,223
GDP at factor cost	**8,316**	**9,414**	**10,203**	**12,770**	**15,713**	**19,349**	**26,285**	**31,320**	**38,806**	**50,838**	**59,450**	**76,243**
Net Other taxes on production	60	71	84	91	126	133	166	154	188	254	334	417
Other taxes on production	60	71	84	91	126	133	166	154	188	254	334	417
Other subsidies on production	-	-	-	-	-	-	-	-	-	-	-	-
GDP at basic prices	**8,376**	**9,485**	**10,287**	**12,861**	**15,839**	**19,482**	**26,451**	**31,474**	**38,994**	**51,092**	**59,784**	**76,660**
Net taxes on products	721	877	914	1,250	1,670	2,012	3,173	2,917	3,485	5,350	6,769	8,925
Taxes on products	1,077	1,247	1,340	1,638	2,083	2,530	3,645	4,283	4,165	5,620	6,918	9,089
Subsidies on products	356	370	426	388	413	518	472	1,366	680	270	149	164
GDP at market prices	9,097	10,362	11,201	14,111	17,509	21,494	29,624	34,391	42,479	56,442	66,553	85,585
Population ('000)	8,387	8,650	8,922	9,202	9,491	9,789	10,096	10,413	10,779	11,150	11,526	11,908
GDP per capita	1,085	1,198	1,255	1,533	1,845	2,196	2,934	3,303	3,941	5,062	5,774	7,187

(Source) National Accounts 1985 - 1996, Central Statistical Office (CSO)

7

FINANCIAL EVALUATION

7.1 Objectives & Scope

The main objective of the financial evaluation is to propose a sustainable and realizable financial scheme that addresses the needs of end-users, the local PV industry (i.e. manufacturers, distributors, and installers), financial institutions, and community-based organizations in Zimbabwe. Given that these sectors represent varying, sometimes conflicting interests, a scheme that strikes a reasonable balance among these project beneficiaries is the targeted output.

This was achieved by reviewing the ongoing UNDP/GEF technical assistance project, taking note of accomplishments and shortcomings for the purpose of building on the former. And a more substantive plan will hopefully be for next phase of the current project.

A review of the experiences of other countries also constituted an integral part of the financial evaluation. Various dissemination modes and financial schemes successfully utilized by other developing economies in promoting the use of PV for rural electrification will be the focus of this review. The result then served as the basis for determining what other finance-related innovations can be applied to Zimbabwe.

7.2 Summary of the UNDP/GEF Technical Assistance Project

Since the UNDP/GEF project inception, it has been the AFC, through its wide network of branches all over Zimbabwe, which has been exclusively managing the project loan scheme, set up to make credit available to rural households and communities at low interest rates for the acquisition of PV systems. A facility called the "Credit Support Facility" or CSF gives the low interest loan. This loan scheme operates on the revolving fund concept, with inputs coming from the initial seed money by UNDP (US$250,000), down payment deposits, installment payments, component purchases, and interest from investments, and outputs going to low-interest end-user loans, payment defaults, and installer fees. All payments are thus made to and disbursed by the AFC. Figure 7-1 gives a clearer picture of the loan scheme.

Beneficiaries of this credit scheme have included individual farmers and households, groups of farmers (with members numbering from 10 to 25 people), registered cooperatives, rural traders and business persons, public institutions such as schools, clinics, and churches, farm compounds in large-scale commercial farms, urban employed persons with families/relatives living in rural areas and safari. But commercial large scale farmers are not covered by the CSF.

7.3 The System of CSF

The AFC provides loans under condition of repayable over a maximum period of 3 years with an initial payment of 15% of system cost. The annual interest rate is set at 15%, well below the prevailing market rate of around 35-40%. It is broken down as follows:

Insurance life cover (covering clients 18 to 65 years)	1.5
Contribution to Credit Support Fund	3.5
Stabilization fund (to cover bad debts)	3.0
AFC's administrative expenses	7.0
Total	15.0%

The credit amount as of November 1997 is as Table 7-1. In 1997 the credit amount increased rapidly.

Table 7-1 The credit amount as of Nov 1997

Term	Acceptance		Permit		Made credit	
	Number	Amount(Z$)	Number	Amount(Z$)	Number	Amount(Z$)
Apr93—Mar94	540	4, 417897	404	2, 790, 493	404	594, 733
Apr94—Mar95	1, 094	10, 061, 715	933	7, 489, 763	917	6, 254, 355
Apr95—Mar96	1, 065	11, 326, 142	767	6, 906, 425	842	4, 175, 580
Apr96—Jan97	1, 765	19, 893, 315	1, 407	12, 895, 068	1, 298	5, 061, 130
Total	4, 464	45, 699, 069	3, 511	30, 081, 749	3, 461	16, 085, 798
(End of Nov97)			4, 206	38, 798, 527		31, 323, 010

Sources: AFC, The data at end of Nov97 is quoted from PMU 1997 annual report

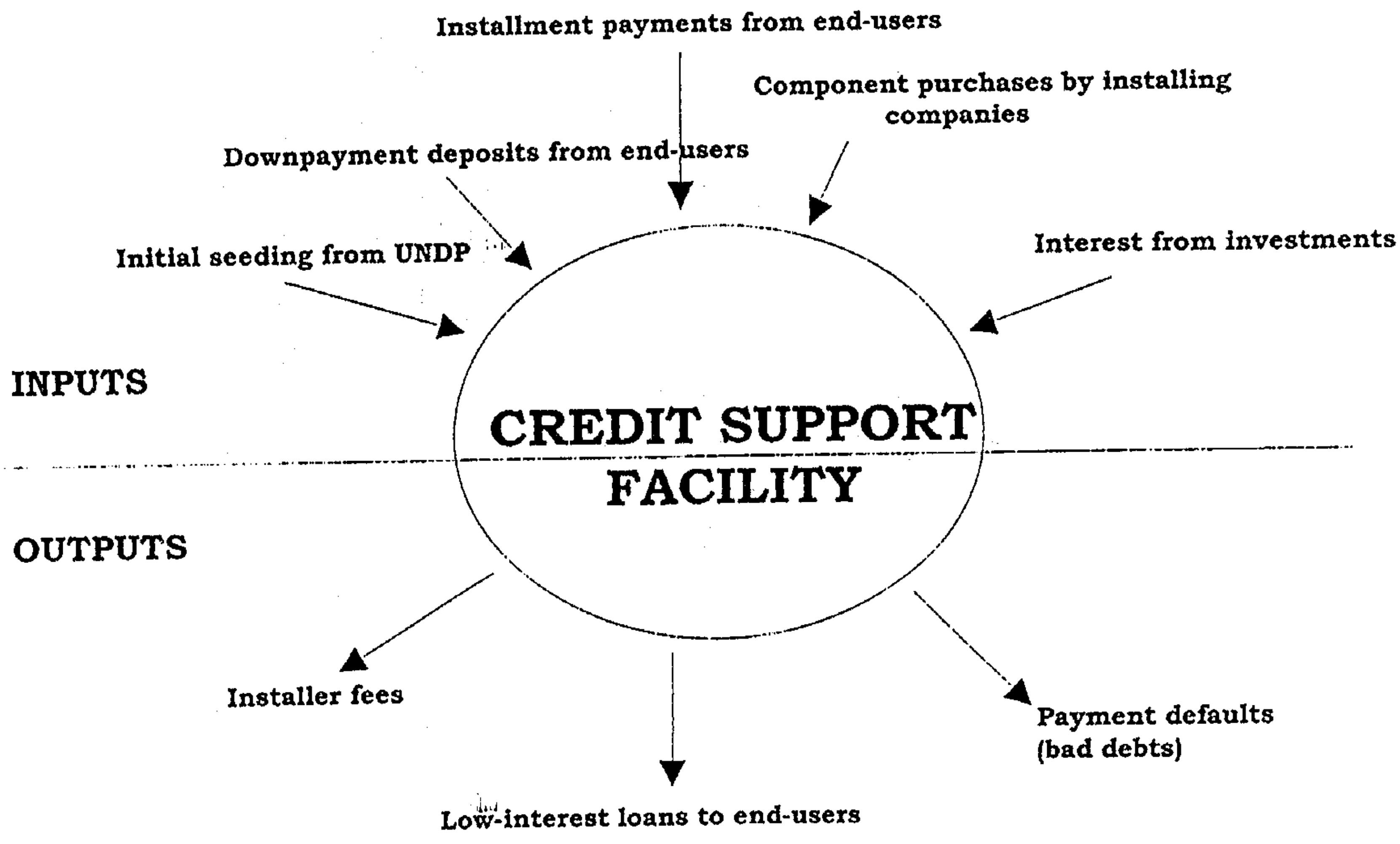


Figure 7-1 Credit Support Facility: Inputs and Outputs

Loan application procedure is as follows;

Approval of loans by the AFC depends on the applicants' submission of the following documents: completed loan application forms, the latest pay slip, and proof that 20% of their net salary is available to meet the installment. To calculate the monthly installment, the AFC uses a factor of 0.034665.

For example:

Total installation cost	=	10,000	=	10,000
Down payment	=	10,000 x 15%	=	1,500
Loan amount	=	10,000 - 1,500	=	8,500
Monthly installment amount	=	8,500 x 0.034665	=	295

To meet the third loan requirement concerning net salary in this example, therefore, the applicant's net salary should be at least Z$1,475 (Z$295x5).

The average turnaround time for loan approval by the AFC is 2 weeks, except in cases where there may be some problems such as failure to meet the technical requirements set by the PMU. To shorten the lead time for processing of loan applications, the AFC recently authorized local PV suppliers/installers to issue loan application forms to end-users themselves.

The basic procedure for the acquisition of PV systems is summarized as follows:

1) Clients interested in PV system obtain technical specifications and price quotations from PV system companies. Clients may also approach AFC in which case they will be referred to companies for quotations.
2) Solar companies present the specifications and quotations to PMU for technical review and approval. Once approved, the client either pays in cash or submits an application for assistance from AFC.
3) Loan application, approved specifications, quotation and pay slip copies are submitted to the AFC office by the client.
4) The application is evaluated and considered for loan granting.
5) Once loan is granted, loan agreement is prepared.

6) Upon signing of loan agreement, the client pays AFC a deposit of 15% of the quoted price for the PV system. A guarantee is then issued by AFC to the relevant solar company.

7) Once the PV system is installed, the PMU inspects the installation and issues a "Completion of Work Certificate" after which AFC pays the concerned company.

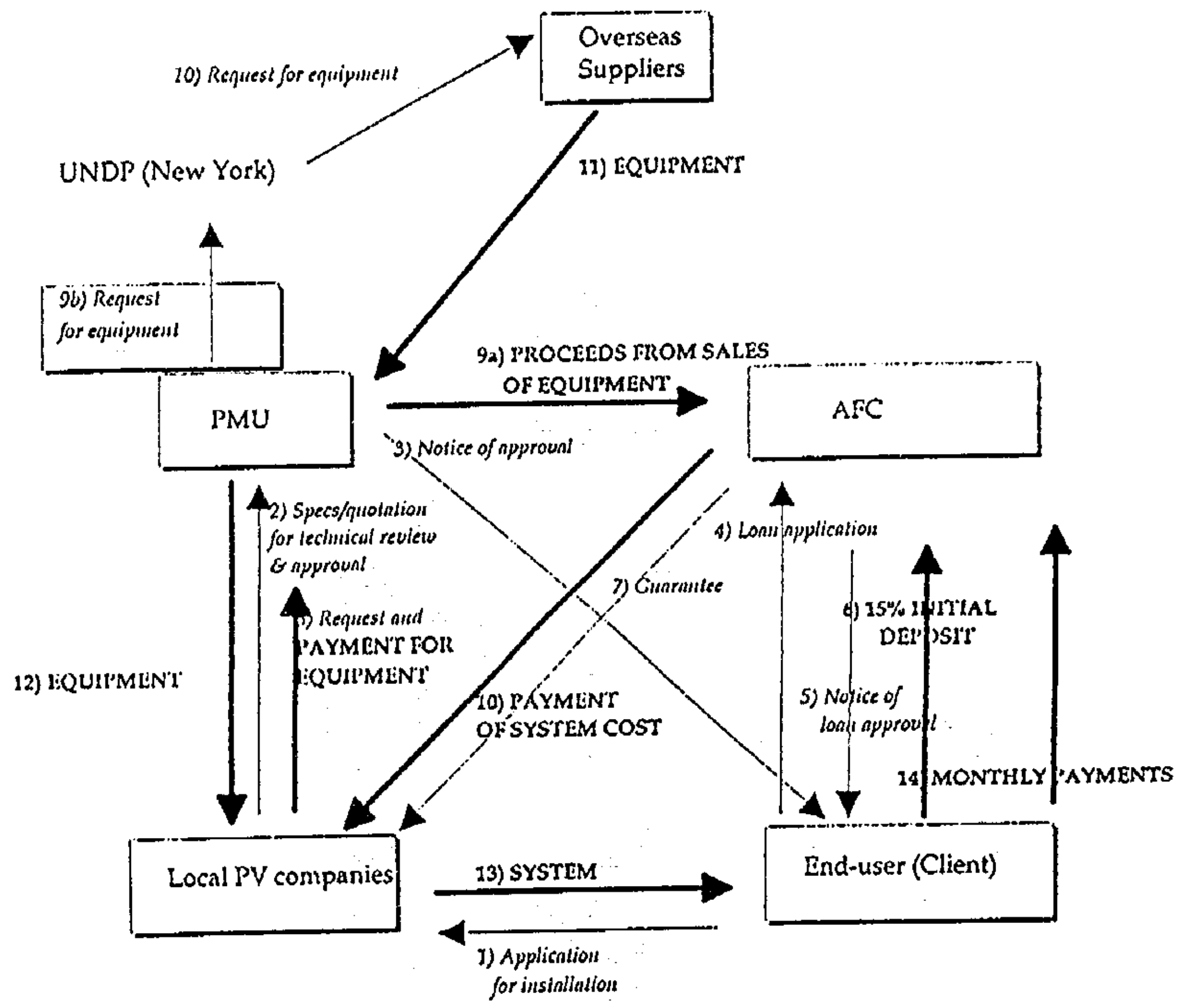
8) AFC branch staff visits the end-user to check systems and loan repayments. Farmers are expected to repay after they sell their produce, while employed or salaried clients are expected to pay monthly through bank/salary stop orders.

9) Solar companies are required by guarantee to visit installed systems at least thrice during the first two years of operation.

Figure 7-2 is a diagrammatic representation of how funds and equipment are mobilized and transferred under the current set-up.

7.4 "Alternative" Modes under the UNDP/GEF Project

An integral part of the financial evaluation is an analysis of the progress of alternative modes under the UNDP/GEF project. This assists an assessment of the viability of other more "innovative" schemes which complement the commercial dissemination of PV systems. Following is an outline of the basic features and terms of each alternative mode, and a description of their early progress in terms of installation and fee collection.



Notes: Solid arrows indicate movement of equipment and/or money.

Figure 7-2 Flow of Funds & Equipment Under UNDP/GEF Project

7.4.1 Public Utility Organization (ZESA)

Under the agreement signed by the Government of Zimbabwe (GOZ), UNDP, and ZESA, ZESA will keep ownership of PV systems, regular maintenance and makes training to the PV system users.

Under the ZESA utility delivery system, a total of 500 systems (45Wp equivalent) will be installed throughout ZESA's 5 areas of operation (Harare, Northern, Southern, Western, and Eastern) in Zimbabwe. As of the second field study in Zimbabwe in June 1997, questionnaires were being administered by a ZESA research engineer to identify potential customers. According to the result of the questionnaires, the beneficiaries of the ZESA solar project will be "consumers in communal, resettlement, and small-scale commercial areas (in Zimbabwe)" including groups of farmers and/or established cooperatives, domestic and commercial customers in rural areas, individual farmers, rural institutions, and any other eligible persons and/or ventures identified.

The scheme shall have a minimum repayment period of at least 5 years and a maximum repayment period of 10 years. The tariff will be determined by ZESA and subject to annual review. The interest has been set at 16% to cover the following items: ZESA administration, Stabilization Fund, contribution to the Initial Investment Fund, Inspection & Research Fund and the Insurance Protection Scheme.

ZESA started their activities from June 1997 and they reached their aim by end of 1997. However, ZESA did not catch up user's request as for being many subscriber.
On the collection of the tariff, it was no problem. Because the tariff collection system of ZESA was made as same as the tariff collection system of grid supplied users. The most of the PV system users were teachers, nurses and professionals.

7.4.2 NGO

Three NGOs, namely BUN, Southern Centre, and the Organization for Rural Progress (ORAP), signed agreements with PMU in late 1996 and early 1997 to install a total of 1,600 PV systems under the UNDP/GEF project.

Harare-based BUN had already installed 30 systems in households in the Chipinge area (southeastern part of Zimbabwe) where it had previously done some biomass-related work. BUN plans to do the rest of its installations in the Eastern half of Zimbabwe, preferably in areas closer to Harare. The target is 200 installations (where 1 system = 45Wp) by the end of 1997. For its part, ORAP, which is based in the city of Bulawayo, had installed a total of 60 household systems at the time of the second field study and is expected to focus on the western part of Zimbabwe in its selection of households.

Unlike BUN and ORAP which are doing most of their work in individual households, Southern Center (which is more of a policy "think tank" rather than a grassroots organization) is focusing on public institutions, particularly schools, for its PV installations under the UNDP/GEF project. Southern Center was still in the process of conducting market research/other preparatory work and had not yet started actual installation work (to commence before the end of 1997). Compared to BUN and ORAP, the capacity of its installations (to be done most likely in areas surrounding Harare in Mashonaland East Province) will be much bigger at 275Wp.

The NGO mode will have a maximum repayment period of 3 years, with interest set at 15% per annum, to cover the following items: 10% administration fee, 3% Stabilization Fund/Insurance Protection Scheme (to be retained as part of the main BUN fund), and 2% contribution to the Initial investment fund (also to be retained as part of the main fund). For net earnings not to be used to repay the project, the NGOs can use it in order to create a sustainable solar revolving fund.

For the first year after installation, the NGOs shall undertake after-service maintenance of the PV systems (with transportation costs charged to the customers). PMU shall provide basic training to BUN, which it will then transfer to customers.

On a positive note for NGO, PV dissemination undertaken so far under the NGO mode has shown great promise in the sense that NGOs are more familiar with the rural areas than are PV companies based in the cities and are thus able to reach more potential customers. To cite an example, BUN's installations in the Chipinge area have been proceeding smoothly mainly on account of its previous experience working with the fruit and vegetable growers living in the area.

7.4.3 CBO (Community Based Organization)

Due mainly to lack of time, PMU stated that it has decided not to start the CBO-based delivery mode in the final fiscal year of the project. It will be pursued, however, should the project go into a second phase.

The use of alternative modes by the UNDP/GEF project was primarily meant to address the needs of the rural poor. The project has not succeeded in this respect, however, as the likely beneficiaries of these alternative modes belong to the same income bracket as those who have been benefiting from the commercial mode. This is, to some extent, explained by the fact that the terms of the commercial and alternative modes do not differ that much. Comparing the commercial and NGO-based modes, in fact, the interest rate and repayment periods are almost identical. The only significant difference is in the required down payment, which is 15% for commercial, and 25% for NGOs.

The basic difference between these two modes lies in the fact that NGOs have a stronger grassroots orientation, enabling them to reach those areas not ordinarily served by PV companies (most of which are based in the main cities/towns). NGOs also have greater flexibility insofar as giving concessions and incentives are concerned. BUN, for instance, treats a 6-month advance as a cash payment (i.e. no interest charged) to encourage customers to pay installments in lump sums. Similarly, for delays in payment caused by droughts or other factors beyond the customers' control, BUN displays greater leniency by allowing the customers more time to come up with the installment without the threat of system confiscation.

Compared to the commercial and NGO modes, ZESA has somewhat different terms – a longer repayment period, slightly higher interest, and its agreement with the customer is such that it retains ownership of the PV systems. One advantage of the utility delivery/financing mode over the others is its wider, more efficient network which spans across the entire country. It also has a stronger technical support base.

Table 7-2 outlines the basic features of all current delivery modes.

Table 7-2 Delivery Modes Under UNDP/GEF Project

Items / Delivery Mode	Commercial Mode (AFC Credit Support Facility)	Alternative Modes: *Utility*	Alternative Modes: *NGO*
Repayment Period	2-3 years	5 years minimum 10 years maximum	3 years maximum
Interest Rate	15%	16%	15%
Initial Deposit	15% of system cost	Not yet determined	25% of system cost
Sources of funds	✓ Initial seeding from UNDP ✓ Payment for system installation by customers ✓ Component purchases by installing companies ✓ Interest earned on investment of funds	✓ Zimbabwe currency equivalent to cost of importation of solar equipment ✓ Payment for system installation by customers ✓ Interest earned on investment of funds ✓ Direct seeding of fund by ZESA to cover initial administrative costs ✓ Direct seeding by the project	✓ Payments for system installation by customers, including: non-refundable application fee of ZS30, minimum deposit, installments, and interest on loans) ✓ Interest earned on investment of funds ✓ Direct seeding by the project
Beneficiaries	✓ Rural groups and cooperatives ✓ Individual farmers ✓ Rural institutions ✓ Business establishments in rural areas ✓ Other consumers (able to pay installments)	✓ Rural groups and cooperatives ✓ Individual farmers ✓ Rural institutions ✓ Business establishments in rural areas ✓ Other consumers (able to pay installments)	✓ Rural groups and cooperatives ✓ Individual farmers ✓ Rural institutions ✓ Business establishments in rural areas ✓ Other consumers (able to pay installments)
System service and maintenance	✓ Solar companies required by guarantee to visit installed system at least 3x during first year of operation ✓ Customer to shoulder transportation costs	✓ ZESA to maintain and replace panels, batteries, charge controller, and accessories ✓ Customer to be responsible for maintenance of internal fixtures ✓ Customer to shoulder transportation costs	✓ NGO to undertake after-sales service ✓ Customer to shoulder transportation costs

Source: MOUs between PMU and ZESA and BUN

7.5 Rationalizing the Use of Subsidies

One crucial policy tool successfully utilized by the UNDP/GEF project was the use of end-user subsidies to ensure successful project take-off. However, with the project in its final year and the institutional framework and basic implementing mechanisms already in place, it now recognizes the need for the current project to graduate into a more substantive phase – one that is largely market-driven – in order to ensure a more sustainable dissemination of PV across the country.

Table 7-3 compares the monthly payments for PV systems under the current AFC Credit Support Facility with monthly payments applying higher interest rates but longer repayment schedules. By increasing the repayment period from the current 3 to, say, 5 years, and increasing the interest rate from the subsidized 15% to the prevailing market rate of 35%, the required monthly payment increases from Z$347 to Z$355, translating into a minimal Z$8 (≈US$0.80) addition to customers' current cash flow requirements. Increasing the interest rate to 30% and the repayment period to 4 years, meanwhile, will raise the monthly payments to Z$360, requiring only an additional Z$13 (≈US$1.30), while applying a 40% interest rate and a 5-year repayment period raises the monthly payment to a still manageable Z$388.

The bottom line is that by phasing out the subsidized interest rate and increasing the repayment period, only a minimal additional amount will be required each month of end-users, which addresses the primary concern of <u>not</u> burdening customers with increased cash flows.

It should be pointed out, however, that a more rational utilization of subsidies, rather than the complete removal of this policy tool, is viewed as the key to ensuring sustainability. As already pointed out, addressing the needs of rural poor is a shortcoming of the current UNDP/GEF project as the project has so far only benefited middle and lower middle income groups. For such needs to be addressed, some assistance in the form of more flexibility in loan repayment schemes – mechanisms which commercial banks are unable to cope with either financially and/or administratively – will be necessary. Continued subsidies targeted towards this particular group are thus easily justified.

Table 7-3 End-User Installments (Subsidized & Non-subsidized Interest Rates)

Subsidized Interest Rate				
Loan Amount (Z$)	10,000	10,000	10,000	10,000
Terms (years)	2	3	4	5
Annual interest rate	15%	15%	15%	15%
Capital Recovery Factor	0.048487	0.034665	0.027831	0.023790
Monthly payment	485	347	278	238
Total payment	11,637	12,480	13,359	14,274
Non-subsidized Interest Rate				
1) 23% interest rate				
Loan Amount (Z$)	10,000	10,000	10,000	10,000
Terms (years)	2	3	4	5
Annual interest rate	23%	23%	23%	23%
Capital Recovery Factor	0.052373	0.038710	0.032051	0.028190
Monthly payment (Z$)	524	387	321	282
Total payment (Z$)	12,570	13,935	15,385	16,914
2) 30% interest rate				
Loan Amount (Z$)	10,000	10,000	10,000	10,000
Terms (years)	2	3	4	5
Annual interest rate	30%	30%	30%	30%
Capital Recovery Factor	0.055913	0.042452	0.036006	0.032353
Monthly payment (Z$)	559	425	360	324
Total payment (Z$)	13,419	15,283	17,283	19,412
3) 35% interest rate				
Loan Amount (Z$)	10000	10000	10000	10000
Terms (years)	2	3	4	5
Annual interest rate	35%	35%	35%	35%
Capital Recovery Factor	0.058519	0.045236	0.038971	0.035490
Monthly payment (Z$)	585	452	390	356
Total payment (Z$)	14,044	16,285	18,706	21,294
4) 40% interest rate				
Loan Amount (Z$)	10000	10000	10000	10000
Terms (years)	2	3	4	5
Annual interest rate	40%	40%	40%	40%
Capital Recovery Factor	0.061188	0.048110	0.042047	0.038752
Monthly payment (Z$)	612	481	420	388
Total payment (Z$)	14,685	17,320	20,182	23,251

Table 7-3 End-User Installments (Subsidized & Non-subsidized Interest Rates)

Subsidized Interest Rate				
Loan Amount (Z$)	10,000	10,000	10,000	10,000
Terms (years)	2	3	4	5
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Monthly payment	485	347	278	238
Total payment	11,637	12,480	13,359	14,274
Non-subsidized Interest Rate				
1) 23% interest rate				
Loan Amount (Z$)	10,000	10,000	10,000	10,000
Terms (years)	2	3	4	5
Annual interest rate	23%	23%	23%	23%
Capital Recovery Factor	0.052373	0.038710	0.032051	0.028190
Monthly payment (Z$)	524	387	321	282
Total payment (Z$)	12,570	13,935	15,385	16,914
2) 30% interest rate				
Loan Amount (Z$)	10,000	10,000	10,000	10,000
Terms (years)	2	3	4	5
Annual interest rate	30%	30%	30%	30%
Capital Recovery Factor	0.055913	0.042452	0.036006	0.032353
Monthly payment (Z$)	559	425	360	324
Total payment (Z$)	13,419	15,283	17,283	19,412
3) 35% interest rate				
Loan Amount (Z$)	10000	10000	10000	10000
Terms (years)	2	3	4	5
Annual interest rate	35%	35%	35%	35%
Capital Recovery Factor	0.058519	0.045236	0.038971	0.035490
Monthly payment (Z$)	585	452	390	355
Total payment (Z$)	14,044	16,285	18,706	21,294
4) 40% interest rate				
Loan Amount (Z$)	10000	10000	10000	10000
Terms (years)	2	3	4	5
Annual interest rate	40%	40%	40%	40%
Capital Recovery Factor	0.061188	0.048110	0.042047	0.038752
Monthly payment (Z$)	612	481	420	388
Total payment (Z$)	14,685	17,320	20,182	23,251

In the final analysis, the main consideration in pursuing this initiative should be the fact that low income consumers have other more basic needs such as food which are naturally accorded more priority than electricity. This considered, group lending through a local NGO or CBO is one option that could be considered since it can realistically reach the rural poor and be financially sustainable at the same time.

7.6 Improving the Local PV Industry's Access to Credit

There are now between 50 and 60 PV companies in Zimbabwe involved in the manufacture, assembly, distribution, and installation of PV systems and components. Size-wise, this figure puts Zimbabwe's PV industry well above those of other developing countries, particularly in the African region. The industry is not without its problems, however. One particular obstacle to its further growth and development is limited access to credit, which could very well affect the overall sustainability of PV use in the country.

Compared to other countries in the African region, Zimbabwe has a relatively developed financial sector consisting of 5 commercial banks, 5 finance houses, 3 building societies, 2 development finance institutions (including SEDCO and the Zimbabwe Development Bank (ZDB)), and 9 merchant banks. There is also a Credit Guarantee Company (CGC) and a Post Office Savings Bank. The Reserve Bank of Zimbabwe (RBZ), which is the monetary and regulatory authority of Zimbabwe, owns part of the CGC, along with the five commercial banks.

Generally speaking, any PV company can avail of credit from these lending institutions. For small companies whose resources are rather limited, however, meeting the terms/requirement inherent in formal sector finance can be rather difficult. Having inadequate physical collateral and a limited (sometimes even non-existent) credit history, they are often viewed by banks as high-risk entities. Transactions costs in these cases can also be quite high relative to the size of loans. On top of these, banks are often unfamiliar with PV technology.

Notably, the AFC offers short-term loans to PV companies at a lower-than-market rate of 30%, which remains constant throughout the life of the loan. The loans should be repaid within a period of 1-2 months, however, as AFC assumes they are used primarily as working capital. (This repayment period can be longer, though, if the loan is disbursed in branches). For security, the AFC allows companies to use movable assets in addition to/in place or fixed assets (which commercial banks normally require). Companies are also allowed to apply for loans as many times as they wish.

In the case of other commercial banks, market rates (ranging from 35-40%) are usually applied to PV loans, with the repayment period ranging from 2-4 years. Loan applicants are usually required to submit projected cashflows for the period of the loan as well as collateral equivalent to the loan amount. To many PV companies, such terms are rather difficult to meet, as reflected in the results of a survey administered by the JICA Study Team to SEIAZ member companies.

All respondents echoed similar sentiments, citing high interest rate, short repayment period, and stringent collateral requirements as the biggest constraints to credit availability. Another shared view of the respondents was the need for a credit facility with more flexible terms, i.e., longer repayment periods, lower interest rates, and more reasonable/no collateral requirements.

Table 7-4 shows the required cash flows for loans extended by AFC, SEDCO, and ZDB. For loans availed from SEDCO, which uses the market interest rate and a 2 to 5-year repayment period, the monthly installment amounts to Z$4,753 (assuming interest = 39%, repayment period = 3 years). Meanwhile, for loans from ZDB, which applies an interest rate of 26-29%, the monthly installment amounts to Z$2,994 (assuming interest = 26% and repayment period = 5 years). (AFC's case is rather different from other banks because, as mentioned earlier, it provides very short-term loans to companies. Monthly cash flows for AFC loans thus cannot be compared to those for loans from other banks.)

Table 7-4 Addressing Local PV Companies' Lack of Access to Credit

AVAILABLE CREDIT FACILITIES

	AFC		SEDCO		ZDB	
Loan Amount (Z$)	100,000		100,000	*15,000 minimum*	100,000	*100,000 minimum*
Terms (years)	0.167	*1-2 months*	3	*2-5 years*	5	*3-15 years*
Interest rate	30%		39%	*35-40%*	26%	*26-29%*
Capital Recovery Factor	0.518827		0.047528		0.029940	
Monthly payment	51,883		4,753		2,994	
Total payment	103,765		171,102		179,643	

FUTURE SCENARIOS

Market interest rates/Varying repayment periods						
30% interest rate						
Loan Amount (Z$)	100,000	100,000	100,000	100,000	100000	100000
Terms (years)	3	4	5	6	7	8
Annual interest rate	30%	30%	30%	30%	30%	30%
Capital Recovery Factor	0.042452	0.036006	0.032353	0.030084	0.028593	0.027577
Monthly payment (Z$)	4245	3601	3235	3008	2859	2758
Total payment (Z$)	152,826	172,829	194,120	216,606	240,181	264,736
35% interest rate						
Loan Amount (Z$)	100,000	100,000	100,000	100,000	100000	100,000
Terms (years)	3	4	5	6	7	8
Annual interest rate	35%	35%	35%	35%	35%	35%
Capital Recovery Factor	0.045236	0.038971	0.035490	0.033379	0.032029	0.031138
Monthly payment (Z$)	4524	3897	3549	3338	3203	3114
Total payment (Z$)	162,850	187,062	212,942	240,327	269,045	298,920
Subsidized interest rate/Varying repayment periods						
23% interest rate						
Loan Amount (Z$)	100,000	100,000	100,000	100,000	100,000	100,000
Terms (years)	3	4	5	6	7	8
Annual interest rate	23%	23%	23%	23%	23%	23%
Capital Recovery Factor	0.038710	0.032051	0.028190	0.025723	0.024047	0.022861
Monthly payment (Z$)	3871	3205	2819	2572	2405	2286
Total payment (Z$)	139,355	153,847	169,143	185,206	201,996	219,467
15% interest rate						
Loan Amount (Z$)	100,000	100,000	100,000	100,000	100,000	100,000
Terms (years)	3	4	5	6	7	8
Annual interest rate	15%	15%	15%	15%	15%	15%
Capital Recovery Factor	0.034665	0.027831	0.023790	0.021145	0.019297	0.017945
Monthly payment (Z$)	3467	2783	2379	2115	1930	1795
Total payment (Z$)	124,795	133,588	142,740	152,244	162,093	172,276

Table 7-4 Addressing Local PV Companies' Lack of Access to Credit

AVAILABLE CREDIT FACILITIES

	AFC		SEDCO		ZDB	
Loan Amount (Z$)	100,000		100,000	*15,000 minimum*	100,000	*100,000 minimum*
Terms (years)	0.167	*1-2 months*	3	*2-5 years*	5	*3-15 years*
Interest rate	30%		39%	*35-40%*	26%	*26-29%*
Capital Recovery Factor	0.518827		0.047528		0.029940	
Monthly payment	51,883		4,753		2,994	
Total payment	103,765		171,102		179,643	

FUTURE SCENARIOS

Market interest rates/Varying repayment periods						
30% interest rate						
Loan Amount (Z$)	100,000	100,000	100,000	100,000	100000	100000
Terms (years)	3	4	5	6	7	8
Annual interest rate	30%	30%	30%	30%	30%	30%
Capital Recovery Factor	0.042452	0.036006	0.032353	0.030084	0.028593	0.027577
Monthly payment (Z$)	4245	3601	3235	3008	2859	2758
Total payment (Z$)	152,826	172,829	194,120	216,606	240,181	264,736
35% interest rate						
Loan Amount (Z$)	100,000	100,000	100,000	100,000	100000	100,000
Terms (years)	3	4	5	6	7	8
Annual interest rate	35%	35%	35%	35%	35%	35%
Capital Recovery Factor	0.045236	0.038971	0.035490	0.033379	0.032029	0.031138
Monthly payment (Z$)	4524	3897	3549	3338	3203	3114
Total payment (Z$)	162,850	187,062	212,942	240,327	269,045	298,920
Subsidized interest rate/Varying repayment periods						
23% interest rate						
Loan Amount (Z$)	100,000	100,000	100,000	100,000	100,000	100,000
Terms (years)	3	4	5	6	7	8
Annual interest rate	23%	23%	23%	23%	23%	23%
Capital Recovery Factor	0.038710	0.032051	0.028190	0.025723	0.024047	0.022861
Monthly payment (Z$)	3871	3205	2819	2572	2405	2286
Total payment (Z$)	139,355	153,847	169,143	185,206	201,996	219,467
15% interest rate						
Loan Amount (Z$)	100,000	100,000	100,000	100,000	100,000	100,000
Terms (years)	3	4	5	6	7	8
Annual interest rate	15%	15%	15%	15%	15%	15%
Capital Recovery Factor	0.034665	0.027831	0.023790	0.021145	0.019297	0.017945
Monthly payment (Z$)	3467	2783	2379	2115	1930	1795
Total payment (Z$)	124,795	133,588	142,740	152,244	162,093	172,276

The lower part of the same table shows various scenarios using more "flexible" terms, i.e. interest rates of 15, 23, and 30%, and repayment periods from 3-8 years. The monthly installment, quite naturally, drops substantially if a lower interest rate and/or a longer repayment period is applied, e.g. Z$2,572 per month assuming a 23% interest rate and a 6-year repayment period, but such terms are not financially viable from the point of view of commercial banks (which naturally have their own interests to protect) without some kind of direct donor or government financing/guarantee program.

The survey revealed that several companies have in the past approached the government-owned CGC, which guarantees 50% of a PV company's total loan amount. Prior to granting such a guarantee, however, the CGC requires an actual loan approval from the involved commercial bank. This basically brings most companies back to square one since the granting of security will hinge on their ability to satisfy the stringent requirements of formal lending institutions.

Among the approaches that may be given some thought to address the credit-related issues confronting the local PV companies include:

1) The first is a donor/government-sponsored credit guarantee fund to increase formal sector financing to PV companies in particular *(to complement work already being done by the Credit Guarantee Company)*;

2) The second is asset-based lending where a PV company obtains a loan by mortgaging its assets *(Since many solar home system enterprises have limited assets, other forms of security such as postdated checks, personal guarantees, bank guarantees can be required in place of fixed assets. A bank may also accept PV systems as partial collateral)*;

3) The third is supplier credits wherein PV module suppliers offer credit to their dealers, usually requiring only a credit application form and some references instead of physical collateral *(The length of credit terms for this type of financing is usually short, at 6 months, but such credit can improve cash flows).*

4) The fourth is an institutional development program for financial intermediaries to strengthen their capacity to assess PV projects (as many lending institutions have insufficient knowledge of PV technology, which in turn influences their decisions regarding the granting of loans to both end-users and PV companies). *(There is an ongoing World Bank project of*

this nature, but it is specifically targeted at increasing credit access for small and medium-scale exporters in Zimbabwe).

7.7 Experiences of Other Developing Countries with PVRE

Worldwide, various national governments and/or multilateral organizations have implemented PVRE projects in many developing countries, producing rather mixed results – some scoring major successes and others failing completely. Table 7-5 summarizes the experiences of some of these countries (including Zimbabwe) in financing PVRE. The rationale behind this exercise is to identify the elements/factors which helped ensure sustainable PVRE financing in other countries for possible application in Zimbabwe.

Based on the table, it is apparent that successful, i.e. sustainable, PVRE financing has been achieved where programs are not heavily dependent on donor/government subsidies, particularly for their operating expenses. Ideally, donor or government support for rural electrification efforts should only come in during the start-up/initial stages of a rural electrification program, e.g. establishment of a revolving fund, technician training, information dissemination, standards-setting, etc.

The experience of Indonesia is a good example of how dependence on government support/subsidies can adversely affect the financial sustainability of a project. Under the heavily-subsidized BANPRES project, users pay an initial fee of around US$25 and a minimal monthly fee of US$3 for a period of 10 years which translate into the repayment of a US$400 loan at zero interest. Although results of the project have so far been satisfactory, some indications of possible future problems are becoming very apparent, particularly concerning fee payments. In addition to this, cost recovery at present tariff levels is a low 50%, translating into a heavy drain on government resources, in effect putting the program's future into question.

Table 7-5 Summary Data on Experiences of Selected Developing Countries with PVRE Financing

	DOMINICAN REPUBLIC	MEXICO	SRI LANKA	INDONESIA	PHILIPPINES	TUVALU	KIRIBATI	KENYA	ZIMBABWE
Type(s) of Financing*	ESCO, Leasing, Consumer, & Cash	Consumer	Leasing, Consumer, & Cash	Leasing, Consumer, & Cash	ESCO	ESCO	ESCO	Cash	Leasing, Consumer, & Cash
Credit Supply	Limited credit provided by NGO revolving funds; NGO loans offer below-market interest rates, will result in eventual depletion of funds. 80% of sales by cash. Most commercial banks do not offer credit for solar home systems, which they view as consumer durable goods.	Credit for agro-industrial and related purposes supplied in the form of "soft loans" by development banks. For use of households and for public lighting, federal government shoulders 50%, state government 30%, & community/ consumers, 20% of total costs (including in-kind contributions).	Very limited access to long-term credit. Bank credit offered at market rates, NGO's rely on revolving funds on-lent at concessional rates. Government programs require modest monthly payment equivalent to the cost of kerosene. 80% of sales by cash.	Credit supplied by government-supported revolving fund; Consumers pay a downpayment and monthly installments for ten years at zero interest. Users expected to purchase replacement batteries when these are required. Fee is comparable to amount paid by utility customers.	Project established revolving fund to finance systems. Financing provided to Rural Electrification Cooperatives (RECs) through the government agency responsible for national electrification.	Project established revolving fund to finance systems.	Project established battery replacement fund wherein users pay a monthly fee, held in escrow, to be used when the old batteries have to be replaced.	Initially donor-sponsored, but now entirely run by private sector. To date, some 25,000 systems have been installed – all on a cash basis to mostly better-off households.	Project established revolving fund to finance systems. Short-term (2-3 year) credit provided by project (commercially and through NGOs) at below-market interest rates, which will result in eventual depletion of fund. Several local NGOs and national electric utility managing their own revolving funds.
Financial sustainability	Good rate of fee collection. PV dissemination being carried out as a commercial, for-profit venture. Revolving credit funds generally effective, but limited due to dependence on donations for initial funds.	Dependent on government grants. Federal and state governments shoulder 80% of costs.	High payment default rate for government programs until strict disconnect policy enforced. Private sector and NGO programs had good cost recovery. Government program subsidized due to zero interest financing.	Full cost recovery not an objective -- currently at 50%. Monthly payments comparable to basic utility services. Average fee collection rate only 60%, though village cooperative or KUD rates ranged from 5 to 95%.	High default rate in initial stages due to technical problems encountered.	Good rate of fee collection, which is basically used to cover operating expenses, but not capital investment costs.	High default rate until strict disconnect policy enforced. Cost recovery steadily improving over the years, from negative balance in the first years of operation, to a healthy surplus in recent years.	Initially government-sponsored. Now, PV dissemination being carried out as a commercial, for-profit venture. Sales have slowed in recent years, however, due to lack of credit for potential customers.	Good rate of fee collection. Cost recovery improving. Revolving fund credit generally effective.
Tax/duty structures	No duty on modules, 100% duty on deep cycle batteries; import restrictions on solar PV components affected cost to customers.	*(data not available)*	High import tariffs.	No import tariff barriers. Fees exclude interest charges. Other organizational overhead costs absorbed by participating government agencies.	Modules and components exempt from import taxes and VAT.	*(data not available)*		*(data not available)*	No duty on modules. 15% sales tax on panels and components.
Others/ Remarks	Commercial approach successful in delivery PV systems to households, but overall scale restricted by limited credit both to the industry and end-users.	Communities responsible for setting up fee collection mechanisms. Ninety per cent of households served by grid supply; PV being supplied on a subsidy basis to areas where grid extension is uneconomic and whose residents cannot afford to pay for systems.	Subsidized cost of systems (equivalent to cost of kerosene) lessened the value that households place on PV systems, making it difficult for companies to sell them at normal prices.	Limited business management capability of KUDs aggravate cost recovery problems.	One of the longest-running PV programs worldwide, but program still widely regarded as a means of pre-electrification rather as an alternative to grid-based electrification.	Demand increasing steadily; fee structure to be revised accordingly. Solar cooperative established as coordinating body for installation, maintenance, repair, and mediation in disputes regarding fee collection.		Government maintains a "hands-off" attitude towards PV-related activities of the private sector. Selling price of PV systems high compared to other countries. In the absence of technical standards or other forms of government support, roughly 25% of systems are no longer functioning.	Demand under commercial mode increasing steadily. Although still in their early stages, NGO and utility modes attracting good end-user response.

- **Electric Service Company (ESCO)** = Electric utilities, cooperatives, NGOs, and private companies buy PV systems in bulk, install solar home systems (SHS), retain ownership, and bill for services.
- **Leasing/Hire-purchase agreements** = An intermediary (private company, cooperative, or NGO) retains ownership of the SHS until paid for by the customer over a period of time. Intermediary often utilizes seed money from government to establish a revolving fund to buy the first PV systems.
- **Consumer Financing** = Customers obtain financing from commercial banks, cooperatives, or vendors to purchase PV systems.
- **Cash** = PV systems are sold directly to customers, who pay the full amount in cash; represents the simplest financial vehicle and shares the advantages/disadvantages of commercial financing.

Selected Sources: *Foley, G (1995) "Photovoltaic Applications in Rural Areas of the Developing World"* *World Bank Technical Paper No. 304* *(Washington DC). Cabraal, A et al (1996) "Best Practices for Photovoltaic Household Electrification Programs (Lessons from Experiences in Selected Countries)" World Bank Technical Paper No. XXX (Washington DC).*

One important issue relating to subsidies is the fact that in many countries, such measures are not actually reaching their targeted beneficiaries -- the rural poor. Instead, better-off families have been benefiting from below-market interest rates, subsidized monthly payments, and long repayment periods typically applied to PV. In the case of Zimbabwe, for instance, the majority of the rural poor cannot afford to make the initial down payment as well as the monthly/seasonal payments for the purchase of PV systems. In their place, middle class families who are actually able (and presumably willing) to pay more in exchange for the many conveniences offered by electric power, have been acquiring the PV systems available under the ongoing UNDP/GEF project for credit at subsidized interest rates. In a situation where the majority of the project beneficiaries belong to the rural poor, subsidizing interest rates and offering other concessions would seem completely justified. Otherwise, allowing normal market conditions to prevail would seem more reasonable.

As shown by the experiences of Kenya and the Dominican Republic, another important element of financially sustainable PVRE programs is good cost recovery. If PV dissemination is carried out mainly as a commercial, for-profit venture, the development of the local PV market is facilitated, and the long-term viability of the program, better ensured.

In the case of Kenya, the large-scale deployment of PV began under a number of government and donor projects, allowing the technology to become known nationwide and providing the basis for the development of local capacities in component assembly and system installation, repair, and maintenance. Soon after, the private sector began to become very actively involved in the supply and installation of solar home systems (SHS's) and since then has been the main hand in diffusing PV systems across Kenya. Sales in densely populated rural areas have grown rapidly, particularly among the wealthy rural middle class.

Conversely, in the case of the Indonesian BANPRES project, cost recovery was never identified as project objective from the outset, so dissemination has relied mainly on government subsidies, as discussed earlier.

A word of caution regarding the preceding discussion, though – it should not be taken to mean that no government involvement in PV dissemination is the ideal situation. On the contrary, some government involvement should be maintained, particularly in the areas of standards setting or other similar forms of regulation. Although the experience of Kenya shows that active private sector participation has provided for very widespread dissemination of PV across the country, the absence of technical standards or other forms of government "support" simultaneously resulted in the entry of many substandard systems into the market. As a result, an estimated 25% of all systems are no longer functioning at the present.

Linked to the issue of cost recovery is the rate of fee collection from end-users. Basically, a good rate of fee collection is crucial to sustainability. To illustrate, in both Sri Lanka and Kiribati, fee collection was a major issue until a strict disconnect policy was enforced. Since that time, a more stable income to the companies involved has allowed for the purchase and installation of more SHS's to meet growing demand. Concerning the rationalization of duty/tariff structures relating to PV modules, the exemption of PV modules from value added tax and import duties is often cited as one factor in ensuring the financial viability of PVRE since it encourages increased PV use by lowering prices. The reduction or removal of import duties and taxes on PV components/kits remains an issue of debate in many circles, however. On the one hand, some quarters believe that PV equipment should be exempted from import duties/taxes since they are used for harnessing a renewable energy source and should thus be given special treatment. This is exemplified by the Philippine experience, where PV panels and components are exempt from value-added tax and import duties. On the other hand, there are those who feel that PV modules and components, being consumer goods acquired by the upper class and middle class families for consumption rather than production, should be taxed accordingly.

Another aspect of successful PVRE financing that can be observed from the experiences of other developing countries is the active participation of local organizations such as cooperatives or NGOs in PV diffusion. In the Philippines, for instance, RECs are actively involved in servicing and fee collection as well as monitoring of the PV systems. Similarly, in Indonesia, KUDs are involved in fee collection, maintenance/repair, and even enforcing disconnections in case of payment default. KUDs are also responsible for contracting private solar home system suppliers for system installation. The advantage that local organizations in general enjoy over national utilities or private companies is that they are better equipped to implement SHS programs in rural areas, having a better knowledge of potential customers and a clearer understanding of the local situation, traditions and customs, as well as limitations. This facilitates fee collection and maintenance.

It should be noted, though, that such kind of active local organization participation is not without its problems. Reports on the BANPRES project, for instance, indicate that many KUDs have not been strictly adhering to contractual obligations and treating disconnects for non-payment differently. All these boil down to the lack of management capability on the part of the KUDs. This is one aspect that should be addressed, therefore, if the full potential of local organizations in PV dissemination is to be realized.

One final observation that can be derived from the above exercise is that type of financing, i.e., lease, ESCO, consumer, or cash, is not so much a deciding element as are other factors like amount of credit supply or rationalization of tax/subsidy structures, among others, for the financial sustainability of PVRE. If anything, a multimodal approach, i.e. utilizing them in combination as is being done in Zimbabwe, the Dominican Republic, and Sri Lanka, helps ensure wider dissemination, as potential end-users of varying employment categories and income brackets have more flexibility in selecting a financing scheme that is most appropriate for their situation, e.g. to pay in cash or avail of credit, to own or lease the PV system, etc.

7.8 Result on the field survey on financing to PV system

7.8.1 Survey on PV Part Suppliers and PV System Installers

A second survey was conducted among PV companies during the final field study to get a clearer picture of the PV industry's situation, particularly in terms of local firms' access to credit/financing. A survey had actually been conducted for the same purpose in mid-1997, but response was very poor (only 6% responded). For the second survey, a number of specific questions were added, and forms were sent directly to the companies, not through SEIAZ as had been done previously.

The response was considerably better this time, with 27 out of the 50 subjects (all GEF-accredited companies), or 54%, returning the questionnaires to the Study Team. Results revealed that most of the companies began their operations as a result of the GEF project (i.e., after 1993, the year the project began) and have less than 20 people in their employ. While their respective net assets vary, most companies' annual revenues fall below the US$10,000 mark.

Forty per cent of the companies have been using their own funds from the start to fund their operations, while 40% availed of short-term loans from AFC. The others obtained loans from other commercial banks like Barclays, SEDCO, and CBZ.

Among the factors identified by the companies as constraints to funding were stringent collateral requirements, lack of understanding by financial institutions about PV, and bureaucracy/red tape. The more commonly cited constraints, however, were high interest rates and short repayment periods. Not surprisingly, the companies suggested low-interest loans for medium to long-term periods with minimal or no collateral required as the kind of government support they need most to address their current situation.

Most companies recognized the benefits brought about by the GEF project, including exemption from import duties, free warehousing services provided by PMU, and greater public awareness about PV. Some expressed apprehension about their future prospects, noting that foreign exchange will be a major problem when they begin to deal directly with overseas suppliers. Most also felt that paying import duties would be a big financial burden. Others were more positive, however, saying that business would continue, albeit with some degree of difficulty in the post-UNDP/GEF scenario.

7.8.2 The Post-UNDP/GEF Scenario

As of the final field study in Zimbabwe, talks were still ongoing as to whether the UNDP/GEF Project (which is already on a 6-month extension) should be extended for a longer period of time. Whether or not this happens, significant changes are expected to happen in the post-GEF period, affecting both PV companies as well as end-users who, as earlier mentioned, have been enjoying a number of privileges under the project.

Companies, for one, will at that time have to begin bearing the burden of paying import duties for imported panels and equipment. An added worry will be warehousing of PV equipment, which was handled by PMU under the UNDP/GEF project. Companies will also have to start handling payment collections directly from end-users (defaults included) – a task that was performed by the AFC under the UNDP/GEF project. These problems will be aggravated by the lack of flexible loan schemes for PV companies among commercial and development banks in Zimbabwe.

End-users, for their part, will no longer have access to loans offered at subsidized interest rates and flexible terms as they did under AFC's Credit Support Fund. The sales tax being imposed by the government on PV equipment is expected to compound their woes.

7.9 Summary & Conclusions

One of the most important lessons learned from the UNDP/GEF project is that subsidies, although well-intentioned, should not be used indiscriminately. As already discussed in the interim report, in spite of its success in promoting greater awareness and more widespread use of PV in Zimbabwe, the UNDP/GEF project has failed to address the needs of the rural poor, with its subsidized end-user loans, benefiting mostly lower middle to middle income groups.

In this kind of situation, subsidies are better phased out since these are income groups that are capable (and presumably willing) to pay for the conveniences offered by electricity. Calculations, in fact, showed that phasing out these subsidies and allowing market rates to prevail would require only a minimal additional cash flow burden the part of end-users. That subsidies are better utilized only for non-repeating or infrastructural expenses or for a program that is guaranteed to benefit low-income groups cannot be overemphasized.

The UNDP/GEF project, which is now on its 6th year, has certainly contributed positively to the rural electrification effort in Zimbabwe by increasing public awareness of the benefits of PV technology. This is validated by actual numbers, showing thousands of households and a significant number of public institutions now enjoying electric power as a result of the project. By its own admission, however, it has failed to reach the rural poor, the intended beneficiaries of the project. Nonetheless, the significance of its overall achievement is substantial.

Undoubtedly, the project has also paved the way for the entry of many new companies in the solar business by granting a number of concessions that gave them easy access to supply and exemption from import duties. They were also spared from the tedious task of dealing directly with customers when it came to collecting payments. While most of these small enterprises are likely to suffer tremendously, possibly even close down, after the project officially ends (and these concessions are removed), some of the fundamentals have already been laid down, and provided the important issues are successfully resolved in the post-GEF period, the industry has the potential for further growth and development.

One of the most important issues that needs to be resolved is the need to increase PV companies' access to finance, which is discussed extensively in other parts of this report. Another is the glaring lack of local technical expertise, which is one of the requisites to a sustainable market. Although some effort was made towards this end, the UNDP/GEF project still failed to develop local maintenance and manufacturing capability. To date, in fact, there is only one major local manufacturer, and most components still have to be imported. It should be noted, however, that these are problems that can effectively be addressed by changes in policy. If the necessary measures are taken to create an "enabling" environment for PV, many local companies can be expected to survive the post-UNDP/GEF period. When such an environment is created, PV will also ultimately be able to reach the lowest income groups in rural Zimbabwe and prove itself as the technology of choice for sustainable rural electrification.

7.10 Recommendations

For PV rural electrification to be truly sustainable in Zimbabwe, concrete steps must be taken by the major players involved --government, local organizations, SEIAZ, and donor organizations

7.10.1 Recommendations to Government

The study team points out two or three recommendation for the Government to make the Government's policies an "enabling" environment to promote installation of PV systems. These are development of RE technologies, to provide financing opportunities for the private sector and to extend duty and tax incentives.

Government, for one, should rationalize the current tax structure by exempting PV modules and components from the 15% sales tax which unnecessarily inflates the costs of PV systems. Exemption from import duties on PV panels and equipment (which were being charged to companies not accredited by PMU during the duration of the project) should also be made a general policy (whether or not the UNDP/GEF project is extended). This is currently being done with basic food items and other selected commodities in Zimbabwe.

The Zimbabwean government must also continue to promote the multimodal approach to ensure flexibility of options available to end-users. As shown by the UNDP/GEF project, the use of NGOs (which have a strong grassroots orientation) and the national utility ZESA (which has a national network backed by strong in-house technical capability) as a complement to the commercial mode, makes it possible to reach a bigger number of customers.

To facilitate the transition to market conditions in the post-GEF period, government must be discriminating in continuing the use of subsidies. Under the GEF project, they benefited only lower middle and middle income groups who could afford the initial down payment and regular installments, and completely failed to address the needs of the rural poor.

A more rational use of this policy tool would be to allow a transition to market rates for lower middle income groups and above since it would only involve a minimal addition to regular installments while maintaining some form of support to the rural poor. The latter could take the form of a flexible loan repayment scheme, carried out by a local NGO or CBO since it can realistically reach the rural poor and be financially sustainable at the same time.

(For example, as shown the below table, in case of installing 9,000 systems priced US$1,000, monthly payment can be decreased from US$36 to US$27 by subsidy to down payment.)

Table 7-6 Comparison of Replenishment to Interest and Subsidy to Initial Cost

(1,000US$)

Case		0	1	2	3	Total	Monthly payment (US$)
Bank rate	Loan	9,000					
	Principal		2,157	2,912	3,931		
	Interest	(35%)	3,150	2,395	1,376		
	Total		5,307	5,307	5,307	15,921	49
Replenishment to interest	Loan	9,000					
	Principal		2,592	2,981	3,428		
	Interest	(15%)	1,350	961	514		
	Total		3,942	3,942	3,942	11,825	36
	Balance					4,096	
Subsidy to initial cost	Loan	4,904					
	Principal		1,175	1,587	2,142		
	Interest	(35%)	1,717	1,305	750		
	Total		2,892	2,892	2,892	8,676	27

To address the issue of limited access to credit by both PV companies and end-users, the Zimbabwean government should initiate the setting up of a credit guarantee fund (with the help of a donor organization) to increase formal sector financing to PV companies in Zimbabwe. A guarantee by the government could effectively influence the decisions of banks, which generally perceive solar projects as a risky undertaking, and result in the granting of more credit to PV companies under more flexible terms. The involvement of an independent body or organization in the management of said fund should be seriously considered to avoid the problem of red tape/bureaucracy.

Government should also explore the feasibility of setting up an institutional development program (possibly in cooperation with a foreign donor) specifically designed for financial intermediaries, for the purpose of strengthening their capacity to assess PV projects. As discussed in earlier reports, many lending institutions have insufficient knowledge of PV technology and the significant economic benefits that can be derived from its use. Such lack of awareness in turn adversely influences their decisions regarding the granting of loans to both end-users and PV companies.

Finally, government must also continue to promote public awareness of the benefits of using PV technology, partly by mandating its use in public offices and facilities. This has been proven effective in other countries (both developed and developing) with active renewable energy programs.

7.10.2 Recommendations to NGO and Local Organizations

Local organizations such as village cooperatives, meanwhile, should contribute to the PVRE effort by proposing specific projects to ward-level selection committees, which are responsible for recommending them to the district council level, which in turn submits a selected list to the provincial government. Efforts, after all, should also be initiated at the grassroots level where community needs, potentials, and limitations are better known and understood.

Given that funds are scarce at the national level, it is also imperative that local communities mobilize their own resources. Experiences of other developing countries have validated that this is possible and even sustainable.

7.10.3 Recommendations to SEIAZ

As the representative body of Zimbabwean solar manufacturers, suppliers/dealers, and installers, SEIAZ should improve its working relationship with government to facilitate members' access to financial and technical assistance, both from government itself and from international donors. Most donor agencies, it should be noted, deal only with national governments rather than private organizations or individual entities.

SEIAZ must also strictly enforce industry standards to discourage the proliferation of companies with substandard products and services in Zimbabwe. A few lending institutions in Zimbabwe have had bad experiences with companies that did substandard work, and have consequently come to regard the rest of the industry in a negative light. Strict enforcement of industry standards would improve the image of local PV companies and eventually enable them to have greater access to formal sector financing.

It would also be beneficial to the industry if SEIAZ were to assume a lead role in proposing specific projects or ideas that would help them since they are in the best position to assess what is most needed, and what will and will not work in the local setting. The organization, for instance, could explore other creative options for internally increasing credit to its members, including asset-based lending, or supplier-credit (whereby module and equipment suppliers offer credit to dealers requiring only a credit application form and some references in place of physical collateral).

7.10.4 Recommendations to Donor Organizations

When providing development aid for renewable energy projects, donor organizations, for their part, should take into consideration the long-term sustainability of the projects they are embarking on. Development assistance, in other words, should be directed at start-up/initial costs that will bring lasting benefits to rural electrification programs, like technical training, information dissemination, and standards setting, rather than paying operating costs. This was one of the most important lessons learned from the experiences of other developing countries with PV based rural electrification.

Donors should also extend assistance that recognizes local manufacturing capabilities. In other words, grants/loans should not be tied to foreign equipment that require foreign maintenance and which will only serve to hinder the development of indigenous manufacturing and maintenance capacity. This is particularly significant in Zimbabwe where local manufacturing and maintenance capacity remain underdeveloped.